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DEPARTMENT OF AGRICULTURE

(HORTICULTURAL BRANCH)

BULLETIN NUMBER 68

DISEASES AND PESTS OF CULTIVATED PLANTS

By J. W. Eastham, B.Sc., Plant Pathologist and Entomologist, and Max H. Muhmann, Assistant Entomologist.

WITH ARTICLE ON

SPRAYS AND SPRAYING

By B. Hoy, B.S.A., Assistant Horticulturist.

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA.

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DEPARTMENT OF AGRICULTURE,

VICTORIA, January 31st, 1916.

To His Honour FRANK STILLMAN BARNARD,

Lieutenant-Governor of the Province of British Columbia.

MAY IT PLEASE YOUR HONOUR:

I have the honour to submit herewith for your approval Bulletin No. 68, entitled "Diseases and Pests of Cultivated Plants in British Columbia, and their Control," which has been prepared by J. W. Eastham, B.Sc., Plant Pathologist and Entomologist, Max H. Ruhmann, Assistant Entomologist, and B. Hoy, Assistant Horticulturist, under the direction of W. E. Scott, Deputy Minister of Agriculture.

I have the honour to be,

Sir,

Your obedient servant,

A. C. FLUMERFELT,

Minister of Finance and Agriculture.

Acknowledgments are due to the Dominion Botanist, Ottawa, for the loan of Figures 3, 4, 5, 6, 7, 8, 10, and 11, which are from various publications of the Division of Botany, Dominion Department of Agriculture.

Diseases and Pests of Cultivated Plants in British Columbia, and their Control.

THE NATURE OF DISEASE.

O accurately define the term "disease" as applied to plants is very difficult. Usually we think of disease as an abnormal condition resulting in weakness and often in death. In the case of plants, we have, however, a less fully unified organism than is the case with animals, and it is possible to have local injury, and even death, of groups of cells without apparent injury to the vitality of the plant as a whole. A good example of this is the bitter-pit or fruit-pit of the apple, which results from the death of groups of cells in the fruit, often without any indications of an abnormal or unhealthy condition in the tree itself. The seeds in such a fruit may also be quite normally developed, so that the amount of "disease" viewed from the standpoint of the life and continuity of the plant is practically negligible. Since, however, the commercial value of the fruit is seriously reduced, bitter-pit is a very serious disease from the cultivator's point of view, however little the life of the plant itself may suffer.

NON-PARASITIC DISEASES.

Plants placed in unsuitable soil, subjected to unfavourable climatic conditions, or otherwise placed in an unfavourable environment, become unthrifty and sickly, and may die as a direct result or fall an easy prey to some parasite. Just where such a condition may be considered as passing into actual disease it is hard to say. Moreover, the full effects of the different factors in the environment on the processes going on in the plant are not very well known. One variety of plant will thrive where another will succumb. Even in the same variety one individual will get along much better than another. Of the constitutional differences which make this possible we know next to nothing. For these reasons few troubles not due to the action of parasitic organisms will be considered here. As a result of horticultural practice and experiment, varieties of plants suitable for certain soils and climates can be selected with reasonable assurance of their fitness, but this, and also the proper treatment necessary to keep the plant in a vigorous condition, falls within the province of the horticulturist. One or two of the more definite diseases of non-parasitic nature, such as bitter-pit and water-core, will, however, be considered in their proper place.

PARASITIC DISEASES.

Most of our destructive plant-diseases are due to the action of organisms which attack the plant in such a way as to abstract from it the food necessary for its own growth and development. In doing this they also introduce poisonous or injurious substances which have a profound effect on the life and growth of the plant. According to the nature of the attack, the plant may be killed outright or in certain members, or may be seriously weakened, stunted, malformed, or otherwise rendered unproductive. The parasites capable of bringing about these changes may be classified under the following four heads:—

(*a.*) Flowering plants.

(*b.*) Fungi, including slime-moulds.

(*c.*) Bacteria.

(*d.*) Insects.

The only flowering plants of practical importance in this Province as parasites of agricultural plants are the dodders, of which the most important are the alfalfa and clover dodders. These will be found to be treated in some detail under "Clover."

The lesions or structural alterations caused by many minute animal organisms, such as eel-worms, pear-leaf blister-mite, and gall-insects, would naturally be included in a study of plant-diseases. Since, however, control measures depend on a thorough knowledge of the life-history of the parasite, such diseases, from the practical economic standpoint, are usually relegated to the province of the entomologist.

FUNGI.

The fungi are a group of plants whose most constant and, superficially, most striking character is the absence of the green colouring-matter (chlorophyll) found in most plants. It is in virtue of this green colouring-matter that the typical plant is able to build up the complex organic materials, such as proteids, starches, sugars, etc., required for the nutrition both of the plants themselves and of animals, from the simple mineral matters in the soil, water, and the gases of the atmosphere. With rare exceptions, plants which do not possess chlorophyll are, like animals, dependent on organic food already manufactured. This they obtain in one of two ways, namely:—

(1.) From living plants or animals, in which case they are said to be *parasites*.

(2.) From dead animal or vegetable matter, in which case they are said to be *saprophytes*.

Good examples of saprophytic fungi are the common mushroom and the moulds to be found only too often on bread, jam, etc. Saprophytic fungi and bacteria play an important part in the economy of nature by getting rid of the dead bodies of plants and animals through the processes of decay and putrefaction which they bring about. The line between parasite and saprophyte is not very clearly drawn, however. There are some fungi which, so far as is known, can only live as parasites of a living plant, and there is a much more numerous group which do not appear to be able to attack living organisms under any conditions. One of the difficulties of the grower in combating plant-diseases, however, lies in the fact that an organism which causes a serious disease may exist for a considerable time as a saprophyte on the decaying organic matter in the soil. Starving out such a parasite by rotation is thus rendered difficult or impossible. On the other hand, a fungus normally a saprophyte may become a parasite under altered conditions. Many fungi, for instance, which probably cannot attack a healthy plant, but which live perhaps on dead wood, can establish themselves in wounds and spread from there into the adjacent healthy tissue.

The structure of a fungus is peculiar in being made up of threads, which usually branch repeatedly. Each thread is termed a *hypha;* the network of threads engaged in obtaining food, as contrasted with those set apart for purposes of reproduction, is termed the *mycelium*. Even such complex structures as the ordinary mushroom, or the hard woody *polypores* or *bracket-fungi*, are made up of closely interwoven, and often hardened, *hyphæ*. In the case of parasitic fungi the hyphæ may be mainly external, sending out little feeding processes between the superficial cells to absorb nutriment from them. This is the case with most powdery mildews. In other cases the hyphæ penetrate the tissues of the *host* (as the attacked plant is termed), passing in between the cells and often entering them or sending out special feeding processes (*haustoria*) into them. In many cases the hyphæ secrete substances which kill the cells bodily, after which their contents are used as food. The late-blight fungus of the potato is a good example. In others the fungus stimulates the cells of the host to increased division and growth, so that enlargements or tumours result; e.g., many rusts, club-root of crucifers.

The slime-moulds differ from typical fungi chiefly in the body not being formed of hyphæ, but, until spore-formation, of a mass of naked protoplasm or living matter, without any containing membrane. As disease-producers they are comparatively unimportant, powdery scab of potatoes and club-root or finger-and-toe of cruciferous plants being the chief diseases due to them.

Fungi reproduce by means of minute bodies termed *spores*, which are, in a sense, comparable to the seeds of higher plants. These spores vary greatly in shape, size, and the manner in which they are produced. They may be spherical, oblong, or thread-like; borne exposed at the tips of special hyphæ, or enclosed in sacs (*sporangia*). Often very special fungus-structures are produced solely with the object of forming and distributing these spores. What we commonly term a "mushroom," for instance, is nothing more than a fructification or reproductive structure, the mycelium or feeding portion of the plant being in the soil—the so-called "spawn." Although spores vary much in size, they are all very minute and easily carried by the wind, rain, insects, etc. Some of the smaller may be little more than 1/25,000 inch in diameter, whilst a very large one might be a hundred times as long by ten times as broad. Often a fungus produces two or more different kinds of spores. The fungus causing apple-scab produces one kind throughout the growing season on the living plant. On the dead leaves, during the winter, a totally different kind develops, to be scattered in the spring. Hence the necessity for knowing the full life-history of the fungus causing a disease, in order to be able to trace back the different infections to their source and take adequate measures against them. Spores which are designed to reproduce the fungus at once are generally enclosed by a very delicate membrane, and usually dry up and die after a short time unless the conditions are right for germination and infection. Resting spores—e.g., for carrying a fungus over winter—are generally thick-walled and resistant to adverse conditions. The method by which a spore germinates to produce a new fungus-plant varies, but generally a delicate hypha (germ-tube) is pushed out, which, if favourably placed with regard to a suitable host-plant, will penetrate into the tissues and develop into a mycelium. A suitable temperature is necessary for this, and, in most cases, a film of moisture such as results from rainfall or dew. This explains why wet weather and moist climates are conducive to epidemics of many fungus-diseases. The whole time between the germination of the spore and the production of new spores from the mycelium so formed may be less than a week, and since the spores are often produced in enormous numbers, it is not difficult to understand the rapidity with which a disease may spread if the conditions are favourable.

BACTERIA.

Bacteria are closely related to the fungi, of which, indeed, they are often considered a group. They differ chiefly in their exceedingly simple structure, each individual being a single minute cell. They multiply (in the case of those causing plant-diseases) by each individual dividing transversely into two, each of which goes on growing until it becomes full-sized, when the process is repeated. Many bacteria (but not those causing plant-diseases) also form spores, but these are of a different type from those of the fungi. The living matter (protoplasm) becomes aggregated together, surrounded by a resistant wall, and enters into a dormant condition. It is a device for resisting unfavourable conditions rather than a means of multiplication. The individuals which result from continued division of one or more original ones may remain together as slimy masses such as are often found on decomposing organic matter. In some cases the individuals remain end to end, forming threads much like fungus-hyphæ.

Bacteria are excessively minute. *Bacillus amylovorus*, which is the cause of fire-blight, has the form of a short rod about 1/16,000 inch long and 1/25,000 inch in diameter. Millions of individuals can, therefore, exist in a drop of liquid, and it is not difficult to understand how the disease may be spread from tree to tree by

insects carrying the sticky ooze on their bodies, or by incompletely disinfected tools. Bacteria have not the same power of directly entering the tissues of plants which many fungi possess, the cuticle or protecting membrane which envelops the greater portion of a plant being sufficient to keep them out. They can only obtain entrance where this has been broken by wounds, insect-punctures, etc., or where it is naturally absent, as at water-pores, breathing-pores (stomata), or delicate structures like nectaries or growing points. Once inside the plant, however, they usually show their effects rapidly, either killing the host-cells outright as in fire-blight, or plugging up the sap-tubes with their masses, thus causing various "wilts." In some cases, however, as in crown-gall, the cells are not killed, but stimulated to increased division, forming masses of abnormal tissue. Owing to the way in which infection takes place, spraying has not the same direct effect in controlling bacterial diseases that it has in many fungus ones. On the other hand, spraying and other measures for the reduction of insect pests are of the greatest importance indirectly, owing to the part played by insects in spreading such diseases. The complete and prompt destruction of affected plants or parts of plants which would otherwise serve as centres of infection is also of the utmost importance.

IMMUNITY AND RESISTANCE.

It is well known that some varieties of a plant are much more subject to certain diseases than are others; in other words, the former are more susceptible and the latter more resistant. Among apples, for example, the McIntosh Red is much more resistant to fire-blight than is the Spitzenberg. This relative resistance, however, may be completely reversed if taken with reference to some other disease; e.g., McIntosh Red is one of the most susceptible of all varieties with respect to apple-scab. Similarly, different individuals of the same variety under identical conditions may show different degrees of resistance to a disease, while the condition as regards growth, nutrition, etc., may make a vast amount of difference. Trees making an excessive sappy growth are much more susceptible to fire-blight; roses subjected to sudden chills are more liable to be attacked by mildew. Resistance is, therefore, the resultant of a complex set of factors, including the nature and constitution of the host-plant, the nature and vigour of the parasite, and the various factors which may modify one or the other. A parasite may be grown under artificial conditions in such a way that it almost or quite loses the power of attacking a living plant. On the other hand, it may be cultivated in such a way that it becomes increasingly virulent.

By immunity we mean a resistance so complete that the diseases cannot develop at all in the "immune" plant. Complete immunity of one cultivated variety of a plant to a disease affecting other varieties of the same kind of plant is rare; e.g., while there is much difference amongst varieties of apples in the resistance they show to fire-blight, there is no variety known which is absolutely immune. On the other hand, the less closely related plants are, the less likely are they to suffer from the same disease. Fire-blight, for instance, is only known to attack plants belonging to the family Rosaceæ. Plants outside this family are immune. The fungi causing apple and pear scab resemble each other so closely as to be practically indistinguishable, but the apple-scab fungus will not produce scab on the pear, and *vice versa*. The *Rhizoctonia* fungus, however, which sometimes causes serious injury to the potato-crop, is apparently able to attack a wide variety of plants, ranging from potatoes to garden asters. It is probable that in future the greatest advances to b made in the control of plant-diseases will be in the development of resistant varieties by means of selection and hybridization. At the same time, it is to be borne in mind that the type of plant desired by the consumer, and consequently by the cultivator, is usually one far removed from the "normal" as seen in the natural plant, and in the nature of things more susceptible to disease. The so-called "improved" plants are usually only such from the consumer's point of view, and not from the standpoint of the vitality of the plant. The juicy, high-flavoured fruit or vegetable usually

means that the protective structures and living matter are reduced to a minimum, while the cells are charged with sugars, acids, and other substances which stimulate the growth of parasitic fungi. Every effort should be made by the grower to secure varieties which are not only commercially desirable, but which have been shown by experience to be resistant under local conditions to the diseases of the locality. In the case of short-lived plants, it is often possible for a grower, by the use of a little care in the selection of seeds or tubers from resistant plants, to develop a strain greatly improved in resistance under the grower's own conditions.

GENERAL METHODS OF PREVENTION.

(1.) Endeavour by proper cultivation, pruning, fertilization, etc., to keep the plant in a thrifty, vigorous condition. This does not mean *forcing*. The production of an excessive sappy growth is one of the most important conditions predisposing to disease, and one which the cultivator in irrigated districts is especially tempted to bring about.

(2.) Collect and burn diseased parts of plants, crop refuse, prunings, etc. Many parasitic or partially parasitic fungi can exist for an indefinite time as saprophytes on such material, only waiting the opportunity to once more attack living plants. Such refuse also harbours all manner of insect pests.

(3.) Try to avoid the first introduction of disease into your land or orchard. Go to some pains to get your stock from a nursery or other source free from disease. Reject any plants that are diseased at the time of setting out. Many diseases are carried in or on seeds and may be widely spread in this way. In some cases it may be advisable to disinfect the seed by soaking it for fifteen minutes in a 1 to 1,000 solution of corrosive sublimate. This will do much to prevent the introduction into this Province of such diseases as club-root or finger-and-toe of cruciferous plants.

(4.) Practise rotation wherever possible. Where a crop has been attacked by some disease, follow it, if possible, for two or three years by crops immune to that disease. In this way many parasites may be starved out. Even where this is not possible owing to the omnivorous character of the parasite, much good may yet be done, since a fungus capable of attacking different crops often becomes increasingly virulent towards one particular crop if allowed to grow and reproduce for generation after generation on that crop.

(5.) *Spraying.*—This is dealt with more fully in another part of the bulletin. Sprays applied to woody deciduous plants during the dormant season are generally made strong enough to kill all spores with which they come in contact. Such sprays, however, are usually so strongly caustic or poisonous that they work serious injury to the soft green parts of plants. Hence sprays adapted for use during the growing season have to be made much weaker. The spray material in this latter case forms a continuous thin layer over the surface of the plant through which the fungus-hypha from a germinating spore must make its way, and in attempting to do so is killed. Spraying of this kind is entirely protective, and must obviously be repeated often enough to keep the film of spray material there and to protect the new growth. It must also be even enough to avoid the occurrence of unprotected spots large enough for a fungus-spore to fall and germinate without coming in contact with the spray film. When the minute size of fungus-spores is considered, it will be realized that this means very thorough spraying. Once a parasite has obtained entrance to a plant spraying can do little or nothing. It is now amongst the cells of the host-plant, and anything which would reach and kill it there would also kill the plant-tissue, so that in a very real sense the cure would be worse than the disease. Superficial parasites like powdery mildews may, however, in some cases be killed by spraying even after they have got a foothold.

(6.) Promptly report and send in for identification any disease with which you are unfamiliar. By doing so you may be rendering the Province a service in reporting the first appearance of a disease which may still be prevented from establishing

itself. At the present time we are fortunate in still being free from a considerable number of diseases which growers elsewhere have to contend with. How long we are to retain this advantageous condition depends very largely on the intelligent interest shown by the grower, as no inspection service that is ordinarily possible is sufficient to keep a continuous oversight of such a large area. In the case of leaves or leafy twigs, lay them out between pieces of newspaper or blotting-paper, and close the package with two pieces of stiff cardboard. Soft fruits, succulent stems, or vegetables liable to be crushed in transit should be sent in wooden or tin boxes. If a number are sent together, each should be wrapped in oiled paper or similar waterproof material. Put your name and address on the outside of the package and send it to the Plant Pathologist, Court-house, Vancouver, together with a letter giving as much information about the extent of the disease, the plants affected, when first observed, etc., as you can.

ALFALFA.

LEAF SPOT (*Pseudopeziza medicaginis*).

Apparently found wherever this crop is grown, but not as yet reported serious. Appears as small, irregular to circular, dark-brown to black spots, chiefly on the leaves, the upper surfaces being most affected. The spots may be so numerous as to involve almost the entire leaf-surface. Badly attacked leaves turn yellow and fall prematurely, so that the yield, when the crop is cut for hay, may be much reduced. Spores are produced in minute fruit-bodies formed in the affected spots.

Control.—No satisfactory means of control are known. When the indications are that the disease is going to be severe enough to produce considerable defoliation if the crop is allowed to stand until the usual cutting-time, it would be advisable to cut earlier, thus avoiding some loss. If the first cutting is affected, but cut early, subsequent cuttings may outgrow the disease.

DODDER. (*See* under "Clover.")

DOWNY MILDEW (*Peronospora trifoliorum*).

A serious disease of alfalfa and related plants in Europe, and also recorded from widely separated sections of America. It appears as large yellowish blotches on the upper surface of the leaf, often involving the entire leaflet. The under-side of these spots is covered by a fuzzy growth of spore-bearing branches (conidiophores) of the fungus, becoming purplish when old. In this Province so far the disease is chiefly of interest in having been found only at one of the driest localities of the Dry Belt, whereas downy mildews are usually associated with moist climates.

WILT OR SCLEROTINIOSE (*Sclerotinia trifoliorum*).

The fungus attacks the stems at or near the level of the ground, producing a local rotting, followed by a wilting of the parts above. If the base of such a stem is examined it will be found covered with a white mouldy growth, and, in this, small irregular nodules of resting mycelium (sclerotia). These are white when first forming, but black when mature. The disease is worst under wet soil conditions, the plants often being killed out in wet spots in the field. No satisfactory control measures are known, but heavy wet soils should be avoided and rotation practised where the disease has occurred. So far the disease is not serious, but it has been found both at the Coast and in the Interior.

CROWN-GALL (*Urophlyctis alfalfæ*).

This disease is quite distinct from the crown-gall found on various kinds of fruit-trees and bushes, and is due to a different type of parasite. So far it has not been found in this Province, but since it is a serious disease, and has been recorded from a number of places in Oregon and California, it is advisable to give some account of it here, in order that growers may be on the look-out for its appearance.

"The disease is characterized by the formation of galls at the crown of the plant. The galls are more abundantly produced at the base of the stem, but may occur on the upper part of the root. The galls in some cases occur several inches above the ground on the stems. They present a very much roughened exterior and vary in size from that of a pea or smaller up to 4 or 5 inches in diameter. In form they are often confluent. Seriously affected plants are killed. Usually the disease will be found in the field in patches in which many of the plants are dead or in various stages of decline. The diseased plants are of a weak growth; the foliage is yellow and the leaves reduced in size."* If any case of this disease is suspected, specimens should be sent to the Plant Pathologist for examination, in order that proper measures may be taken for its eradication should it be introduced.

APPLE.

ANTHRACNOSE (*Neofabræa malicorticis*).

This disease, also known as black-spot canker and Pacific Coast canker, is apparently confined to the Pacific North-west. In this Province it is serious only in the Coast and Island sections, although it also occurs at various points in the Interior. The disease may attack the fruit, causing a rot, but the chief injury is done by the formation of cankers on the tree. These are most abundant on the smaller branches, but may occur on the larger limbs or on the trunk in the case of young trees. Complete girdling often results, usually from two or more cankers becoming confluent.

Infection takes place at the time of the fall rains. Small injuries may facilitate this, but are not necessary, the fungus being capable of penetrating uninjured bark, probably through the lenticels in most cases. The first apparent result of an infection is the formation of a small, circular, reddish-brown spot on the bark, extending to the underlying tissues. The development of these incipient cankers is arrested during the winter months, but when the sap begins to rise in the spring activity recommences, the canker extending most rapidly up and down the branch. By the time growth becomes active in the tree the cankers cease to extend, and a well-marked crack is formed, delimiting the canker from the surrounding healthy tissue. The surface of the canker is now shrunken and shrivelled. The dead substance gradually disintegrates and falls out, although remains of it may cling to the wound for two or three years. If the cankers have not been too large the wounds will gradually heal over, but in the case of large wounds there is danger of various wound-parasites entering before the healing process is complete and setting up decay in the wood.

From the above it will be seen that the canker is only annual in its activity. The fungus, however, continues to live for two or three years in the dead tissue of the canker, producing large numbers of spores which may bring about new infections. During summer numerous little pustules appear on the surface of the canker, beginning at the centre of the area, and later extending to its margin. The bark at these points finally cracks, exposing an underlying mass of fungus-tissue from which the spores are produced. These are mature in late summer or early fall, and are scattered by wind and rain. Cankers one year old or more, therefore, while in no danger of directly spreading, are a fruitful source of new infections.

On the fruit the fungus causes a rot which may occur both in cellar and cold storage. Typical rot has also been recorded in apples still on the tree.

Control.—Since the canker is an annual the most important thing is the prevention of new infection. Spraying with double-strength (8-8-40) Bordeaux mixture is the most effective means of protection, but it must be done before the fall rains begin. Where the disease is bad it may be necessary to repeat this after an interval of one or two weeks. Where late varieties are grown it may be too late to be of much use if left until the fruit is picked. Lime-sulphur seems to be much inferior

* Biennial Crop Pest and Horticultural Report, 1911-12, Oregon Agricultural College Experiment Station.

to Bordeaux mixture for this disease. Badly affected branches should be pruned out. In the cankers that remain the dead material should be cleaned out as far as possible and *burned*. If merely thrown on the ground there is a possibility of spore production still taking place. Wounds, if large, should be protected with grafting-wax or paint. Where the number of cankers is very great, keeping them painted over is a quicker method and seems fairly satisfactory in preventing the formation of spores. If the surface layer is shaved off incipient cankers noticed in winter or early spring, many of them will dry out and not develop further. Pruning should be done as early as possible and the prunings removed and burned, otherwise they may prove a source of future infection. Fallen fruit should be gathered up and destroyed.

BACTERIAL BLIGHT (*Bacillus amylovorus*).

Also generally known under the names of fire-blight and pear-blight. Circular 23 of the Department of Agriculture deals fully with this disease and should be studied by every grower in any district where it occurs or is likely to be introduced. This circular, however, was intended mainly to give information about the disease and the method of controlling it to the grower as an individual. With some diseases there is little danger of one man's neglect directly causing serious material injury to others, and in such cases it is a matter for the grower himself to decide how far he will take measures to control the disease. Even though he chose to lose his entire orchard there would be no call for the Government to interfere. Among plant-diseases, however, fire-blight stands in a class by itself in the extent to which it can be spread from a centre of infection and in its destructive results. For these reasons the control of blight cannot be regarded as an individual problem, but must be considered a community one, rendering necessary the application of coercive measures if requisite to ensure prompt removal of sources of infection. The Provincial Government has from the first taken this view, and by its legislation and inspection service endeavoured to protect the interests of the community. Compulsion, however, is not desirable, except where all other means have failed, though it is usually most resented by those who have taken least trouble to understand the nature of the case, or who have least at stake. At the same time, blight is excessively variable in its behaviour, varying with the variety and age of the trees, cultural conditions, irrigation, rainfall, etc., so that it is practically impossible to lay down hard-and-fast rules to fairly meet all conditions; while the action of an Inspector in making distinctions between different cases is liable to subject him to criticism on the grounds of favoritism or inconsistency. It has therefore been thought desirable to discuss here in a general way, referring the reader to the above-mentioned circular for details, the subject of blight-control, with especial reference to debatable points and the limits within which individual liberty of action is permissible in dealing with it.

It cannot be too often or too strongly emphasized that the only known means by which the disease can persist from one season to another is in the "hold-over" cankers on the larger branches, trunks, and roots. Thorough work in removing these sources of infection is the only sure way of preventing an epidemic the following season. *If all such "hold-overs" in a district could be removed, blight would disappear until reintroduced from outside.* This work is done whilst the trees are dormant, but the actual time for doing it may be left to some extent to the individual grower. In no case, however, must it be left until the season is so far advanced that thorough and deliberate work cannot be completed before the sap begins to rise. Many growers combine the operations of blight-cutting and winter pruning, but there is something to be said in favour of getting the blight cleaned up first. Blight-cutting requires more care and skill than ordinary pruning, and if the blight is out there is less danger of careless work resulting in new infections unless all pruning-wounds are also disinfected. As soon as the fruit has been picked an inspection

should be made to determine whether root, crown, or serious trunk-infection exist. The condition of the foliage is often of value in indicating the presence of such cases, while proper inspection of the parts below ground is difficult or impossible after the ground freezes. Trees which are to be taken out should be marked at this stage in order that work may not subsequently be wasted on them. The cutting-out of the cankers is best done when the leaves are off, as they can then be seen better. The dead leaves often persist for a considerable time on the blighted twigs, and if the work is begun as soon as the leaves fall, these persistent ones facilitate the finding of some of the blight. The extent of injury which makes it preferable to take a tree out rather than to treat it depends very largely upon the grower himself. If sufficient skilled work can be spent on them, bad cases of body-blight and even of root-blight may be saved. Even trees completely girdled may have the diseased parts cut away and the means for sap-flow re-established by bridge-grafts. In this connection, however, it is to be noted that unsuccessful work is just so much labour thrown away, and it is probably best for the average grower not to attempt to treat any cases of the disease at or below the ground-line, but to take out the tree. When cutting during very cold weather some growers have considered it unnecessary to disinfect the cuts. This, however, cannot be recommended, as it is not free from risk. It is quite true that trees in the dormant condition are much less susceptible to infection, but the blight bacillus can survive without serious injury temperatures as low as 40° Fahr. The only permissible exception would be when the temperature is so low as to solidify the aqueous solution of corrosive sublimate before it can be applied, and even in such cases it would probably be wise to go over these wounds subsequently with a disinfectant. Even if every care is exercised, it is not sufficient to do thorough work and then leave it. No blight-cutter is expert enough to remove, at one cutting, every case of "hold-over" in an orchard of any size, if the blight has been at all severe. The grower should go over his trees at intervals, when the light is good, in order to detect and remove anything that has been missed. This is especially necessary after the sap has begun to flow, as missed "hold-overs" or imperfect work may often be revealed at this time by their moist appearance. A very careful inspection should be made just before blossoming-time, as much blossom-infection may be saved by the detection of an active canker at this time. A careful watch should also be kept for the first appearance of blossom-blight. If this should occur in spots, it is often possible to trace the infection to some centrally placed "hold-over" which has been missed. The removal of this may still prevent some infection. Where there is only a little blossom-blight it may be removed by cutting off the infected spurs, but for this to be successful it is essential that the disease should not have passed beyond the spur into the branch bearing it, or, if so, that the limits of the infection be accurately determined and the cut made accordingly. It very frequently happens, also, that the disease dies out in the blossom, or the spur, without extending farther. For these reasons, if blossom-infection is at all abundant, it is best to leave it for the time being, watch it very closely, and cut out at once any infection that begins to "move." Twig-blight should also be cut as it appears. Where the work in the dormant season has been thorough, the amount of blossom and twig infection should not be too great to permit of its prompt removal. Where, for any reason, however, the infections are very numerous, many of them may dry up and apparently die out before they can be attended to. The question now is, whether, especially if the season has reached late summer, such dried-up infections may be left until the clean-up in the dormant season. There is no doubt that successful results have been obtained in certain districts in certain seasons by so doing, and with greater economy since the pressure of work is greater at this time, and the loss of fruit from working in the trees at this time may be considerable. More care is also necessary over the work, and there is greater wastage of tree-tissue than in work done during the dormant season. At the same time, especially in irrigated districts, there is a danger of many apparently dried-up infections starting

into new activity. As regards irrigated districts, it may be said that up to and including any activity which may be induced by the last irrigation during the growing season, no active blight may be left. Infection that has apparently dried up may be left, subject to the approval of the Inspector, and on the distinct understanding that should it once more become active it must be removed without delay. In non-irrigated districts it may be possible to allow rather more latitude as to the time when infections may be considered past spreading. While it may under certain conditions prove economical to leave the blight for a time, it must be understood that this is not a safe practice, and can only be permitted when the grower has the situation well in hand. The stringency of the regulations is not directed towards compelling a grower for his own good, but as a protection to neighbouring orchardists. As long as actively growing trees have blight exudate in their vicinity and insect pests are present, it is possible for such trees to be infected, thus causing loss to a grower in spite of every care on his part. In some varieties of apples—e.g., Spitzenberg, Wagener, and Crabs—and in many varieties of pears, blight may continue to work as long as the sap flows. In his own interest it would be better for the grower to endeavour to stop the loss of tissue by proper cutting. If, however, the season is advanced, and with a knowledge of all the circumstances, such as the condition of the nearest orchards, the number and kind of insect pests, etc., the Inspector does not consider that the orchards of others are endangered, it may be permissible to allow the disease to run its own course, provided that a thorough clean-up is made during the dormant season.

CROWN-GALL (*Pseudomonas tumefaciens*).

This disease attacks a large variety of plants, including most of our tree and bush fruits, and is transmissible from one to the other; e.g., from raspberry to peach. It consists of a swelling or gall, usually on the roots or at the crown of the plant, although it may also occur on parts well above ground, especially in the blackberry. On the apple, in addition to the typical gall, an abnormal condition known as "hairy root" may be found. This is due to an excessive formation of branch roots, of a somewhat fleshy character, from the infected main root or crown. "Hairy root" is due to the same parasite as the typical gall, but may or may not be associated with it in the same plant. The galls themselves are of two types, a soft form which rots away each year, and generally grows again at or near the edge of the old wound, and a hard woody form which may persist for many years. Peculiar excrescences occasionally seen on the limbs of apple-trees are probably due to the same disease, infection having been produced by insects.

On the apple the disease is chiefly serious on nursery stock, plants at this stage being apparently more susceptible, and the wounds made in grafting and budding affording a better opportunity for infection. The extent to which an affected tree is injured is a somewhat disputed point. There is no doubt, however, that a galled young plant has a much poorer chance of developing into a vigorous tree than has one free from the disease, while if the galls are cut off the root system is liable to be so much injured as to seriously check the growth of the tree. It is, however, true that a tree may outgrow the infection entirely, and that an established tree may have a certain amount of galls on it without showing any ill effects. Large galls, however, especially around the crown, interfere with sap-conduction, and also offer favourable opportunities for the entrance of other diseases, particularly fire-blight.

Control.—Soil known to be infected should not be used for growing nursery stock. As little opportunity as possible should be given for galls to decay in the soil, since by this means the soil becomes infected. Affected stock should not be planted out, but destroyed. On older and apparently thrifty trees galls may be left alone unless exposed to fire-blight infection. In such a case they should be cut out completely, an inch or more beyond the edge of the gall, and the wound disinfected and painted over.

Fig. 1.

(*a.*) Crown-gall on nursery stock.

(*b.*) Hairy root on young apple-tree.

SCAB (*Venturia inæqualis*).

A generally distributed pest, its importance, however, being dependent on climatic conditions. In the Island and Lower Mainland it is a factor to be constantly reckoned with, as also at many points in the Interior. In the Dry Belt it has usually been considered a negligible disease, but it has recently caused much loss at Vernon and Kelowna. The rainfall in these districts in a wet season is sufficient to provide the requisite conditions for a bad attack of scab.

The disease is due to a fungus which may attack the leaves, flowers, fruit, and twigs. On the leaves it forms dark olive-green spots which may be circular or irregular in shape. They are usually more irregular and less clearly defined on the lower surface. Under a lens each spot may readily be seen to consist of the radiating branched threads (*hyphæ*) of the fungus. From these, summer spores (*conidia*) are produced, which in turn give rise to new infections. The assimilating power of a leaf so attacked is much reduced, and if the attack is severe, premature yellowing and fall of the leaf results. Serious loss may result from the disease attacking the flower-stalks, causing the flowers to fall off instead of setting fruit. On the fruit

the disease is probably best known and most directly injurious, such fruit being much reduced in market value. The spots are circular, or nearly so, and dark olive to black in colour. The dried remains of the cuticle are often visible around the margin of the spot. Cracking of the fruit at the affected spots often follows and may lead to the formation of large cracks right across the fruit if the spots are numerous. When the infection takes place early and is at all severe, it may cause serious malformation and stunting of the fruit. Twig-infection is not common with us. Throughout the season conidia are formed on the spots, and new infections may take place if the conditions are suitable. On stored fruit old infections may increase in size and new ones may also occur. Owing to the removal of the protecting cuticle at the affected spots, such apples shrivel sooner than sound ones, and rot-fungi, particularly the pink-rot (*Cephalothecium roseum*), can readily obtain an entrance.

Fig. 2. Apples affected with scab. No. 2 shows the skin of the apple, split off from the underlying tissue, persisting round the edge of the fungus-spot. No. 3 shows the cracking which often supervenes. Both 3 and 4 show malformation as a result of scab-infection.

After the affected leaves have fallen the fungus in them undergoes a further development during the winter months, giving rise to spores of a different kind (*ascospores*). These are first liberated about the time when the blossoms are opening, and over a period of perhaps three or four weeks. The first infections each season come almost entirely from this source.

Control.—This is a typical case of a disease controllable by preventive spraying. The spores germinate and produce infection throughout the growing season if moisture conditions are favourable. To prevent this it is necessary that all susceptible parts be kept covered with a suitable fungicide as long as climatic conditions are such as to favour new infections. Owing to the difference between one season and another, one of the chief difficulties is to judge correctly the number and times of application of the sprayings required; two sprayings may be sufficient in one season where three or four might be required during the next. Bordeaux mixture is an effective spray material as far as the control of the disease goes, but often causes serious russeting of the fruit, and for this reason has been largely superseded by lime-sulphur for sprayings after blossoming-time. Since infection comes from the fallen leaves about blossoming-time, the "dormant" spray with lime-sulphur has little effect in controlling scab, although it may destroy a few overwintering conidia. The important sprays are as follows: First, when the blossoms are well separated in the cluster, showing pink, but still unopened. Lime-sulphur solution 1 to 30 or Bordeaux mixture 4-4-40 may be used at this stage, as there is little danger of russeting. Second, when last petals are falling, with lime-sulphur 1 to 30 or 1 to 40, according to circu-

stances, the stronger solution being used if there is reason to anticipate an epidemic. Third, the same strength applied ten to twenty days later, according to the weather. Additional sprayings may be necessary with very susceptible varieties or continued wet weather. These should be given when the spray materials from the previous sprayings begin to get washed off. In most places in the Interior in a normal year the first two sprayings are sufficient. A difficulty lies in the long period in certain seasons between the breaking of the buds and the opening of the blossoms, which gives time for infection to take place before the first spray is applied. Good results, therefore, have been obtained in some cases by spraying when the buds are unfolding. Where infections have taken place, subsequent sprayings, whether with Bordeaux mixture or lime-sulphur, may produce very serious "burning" of the leaves, since the fungus injures the epidermis in such a way as to allow the spray material to come in contact with the delicate internal cells.

Proper pruning and good air-drainage are important. Destruction or ploughing-under of the leaves in fall or early spring, if practicable, reduces infection. Certain varieties are very susceptible, notably the Fameuse (Snow) and McIntosh Red. These should not be planted where scab is bad, unless special care can be given to controlling the disease.

POWDERY MILDEW (*Sphærotheca mali*).

This forms a greyish-white mouldy growth on the surface of the parts attacked. From this growth summer spores are produced in large quantities, so that it seems powdery to the touch. Late in the season small, round, black fruiting-bodies of a different type and capable of carrying the fungus over the winter may be formed in the felted mycelium. The fungus mainly persists over the winter, however, in the form of mycelium on the twigs. The young shoots are chiefly affected, but the fruit may also be attacked. Such shoots are stunted and the leaves smaller than normal. The Jonathan seems to suffer most. This disease is widely distributed in the Province, but is most pronounced in dry districts. It has generally been considered of almost negligible importance, except on nursery stock, but latterly has become quite serious on orchard trees in some localities.

Control.—Powdery mildews are superficial parasites feeding only on the external cells of the host. Most of them are on this account easily controlled, sulphur and its compounds being particularly effective. Apple-mildew, however, is an exception, although where the dormant spray with lime-sulphur and one or more scab sprays with the same substance are given it ought not to be serious. Latterly Atomic Sulphur has been strongly recommended against this disease, but we have no experimental data as yet regarding its efficacy under our conditions. Diseased twigs should be pruned out during winter pruning.

SILVER-LEAF.

This is a condition which may affect a considerable variety of fruit-trees, stone-fruits being considered especially liable to it. In British Columbia it is commonest on the apple, but also occurs on apricot, peach, and pear, and has been reported on cherries. The disease has received its name from the peculiar appearance of the leaves on an affected limb or tree. Instead of being of a normal green colour, they have a leaden or silvery appearance. The intensity of this may vary very much, being in some cases hardly noticeable except by close observation, while in others the tree is conspicuous at a distance. The alteration in colour is apparently due to the separation of the epidermis from the underlying cells, thus permitting the presence of air-spaces which mask the normal green colour. The cause of silver-leaf has been much discussed. It was formerly supposed to be purely physiological, but recent work, both in Britain and Eastern Canada, has shown that many cases, at any rate, of the disease are associated with the presence of the fungus *Stereum purpureum*, and that inoculation of this fungus into healthy plants can reproduce the disease.

There seems no doubt, therefore, that this fungus is the cause of one form of the disease. The fungus is not present in the leaves themselves, but in the wood of the trunk or limbs, and the effect is presumably due to some toxic substance produced by the fungus and carried to the leaves in the ascending sap-stream. It is apparently only a saprophyte or wound-parasite and obtains entrance through some injury, such as certain forms of winter injury. The fruiting-bodies only appear when the part attacked is dead or dying. They are in the form of small brackets, half an inch or less across, white above, smooth and crimson to purple in colour on the under-side, and often massed together one above another for a space of several inches. It is generally stated that where one limb is affected, that limb ultimately dies, while in the meantime the disease may have spread so as to have involved the whole of the tree. Where the whole tree is affected the tree dies. Cases of spontaneous recovery have, however, been noticed. Treatment is only possible where one or more limbs are affected without involving the rest of the tree. In such cases the affected limbs should be cut out and burned. Since the fruit-bodies are produced only on dead or dying wood, such as old stumps, it is important that all such material be destroyed and not left to provide a medium for the development of this and other potential parasites.

While the above outline of the nature and cause of the disease may be correct in many instances, there is evidence that much of the silver-leaf in British Columbia is due to other causes. In particular, a mite working on the leaves has been found to produce a similar effect. In the earlier stages this can be distinguished by the "silvering" occurring in patches where the mite is working, thus producing a mottled effect. In old cases, however, the leaf tends to become uniformly silvered and apparently identical with typical *Stereum* silver-leaf. This may explain the absence of silver-leaf from trees reported previously as badly affected. In view of the statement that true silver-leaf cannot be successfully treated, the following experiment may be of interest: Two five-year-old apricot-trees in an orchard at Naramata showed silver-leaf slightly in 1913. In May, 1914, they showed it very badly, every leaf being uniformly and strongly silvered, and the symptoms apparently those of typical *Stereum* silver-leaf. Late in May these trees were treated by applying 7½ lb. of sulphate of iron to each, the dry crystals being scattered over the surface of the soil up to a radius of 10 feet from the tree, and then worked in. According to the account of the experimenter, "By the middle of June there was a marked improvement in the new growth; it showed more vigour and the new foliage was perfectly clean. The trees matured a heavy crop of first-class fruit." This year the owner states the trees are free from disease and have borne a heavy crop. This treatment is, we believe, based upon recommendations issued by the Department of Agriculture of New Zealand. Whether it is really curative or merely postpones the final result cannot as yet be stated, but it is worthy of further trial. It has already been stated that the *Stereum* fruiting-bodies only appear on dead or dying wood, and so long as this is removed as it appears there is no danger of other trees being infected, and consequently no danger in making such an experiment.

COLLAR-ROT.

It not infrequently happens that a tree dies or appears unhealthy without apparent cause. Examination of the trunk at or below the ground-level may show, however, that the tissues of the trunk and probably of the main roots are dead, the dead areas being of variable extent and often extending right around the tree. Complete girdling is, of course, followed by the death of the tree. The cause of the trouble may in some cases have been fire-blight which has spread down to the crown or roots by infection of water-sprouts or suckers. The blight-infection may then have died out and given place to various rot-fungi. In most cases, however, this "collar" injury is due to freezing or alternate freezing and thawing, and is a form of winter injury. While fungus mycelium is commonly present in the dead tissues, very few

cases have been noticed in this Province, which could be put down to mushroom root-rot (*Armillaria mellea*). In none of the cases noticed by the writer was it possible to find either fruiting-bodies or rhizomorphs. This is rather surprising in view of the frequency of the disease in the Pacific States and the undoubted presence of the fungus with us. Very little can be done in cases of collar-rot, the tree being generally in a dying condition before the injury is noticed. It is desirable that the trees be so treated that the wood is well matured by the time cold weather sets in, as late growth and a sappy condition of the tree predispose to all kinds of winter injury.

FRUIT-PIT.

Also known as Baldwin spot and bitter-pit. This is one of the commonest diseases of the apple fruit, being found more or less in all districts. It is probably worst in the irrigated districts, although it may be very severe at times elsewhere. In its usual form the disease appears as sunken circular spots, ⅛ to ½ inch in diameter, on the surface of the fruit. These are often darker in colour than the surrounding surface, at least in the later stages. The skin over the spot is usually unbroken. The tissue beneath the spot is dead and brown, and similar pockets and streaks of dead tissue are generally found scattered through the interior of the fruit. In some cases an apple may be very badly affected in this way with little or no indication of the disease on the surface. In many cases, apples, apparently without blemish when picked, develop the disease in storage. The name "bitter-pit" has been given to it from the bitter taste which the pitted spots are stated to have. This does not seem to be the case with us, the chief injury in most cases being to the appearance and consequently the market value of the fruit. A peculiar form of "core-rot" or "dry-rot" found in certain sections is probably due to similar conditions. Cases may be found where one limb of a tree bears badly pitted fruit, while that on the remainder of the tree is either free from the disease or much more lightly affected. There is considerable difference in the susceptibility of different varieties, although none is entirely immune. Northern Spy appears to be one of the worst, but this may in part be due to most of the trees of this variety not being yet in full bearing. Jonathan and McIntosh Red suffer very little from it, this being another strong point in favour of the latter as an apple for irrigated sections.

The disease occurs in Europe, South Africa, and Australasia, in addition to North America, and has been studied by many investigators. A great deal has been written on the subject, but as yet the relationship between the factors which cause it and the development of the disease has not been defined with sufficient clearness to render possible any very definite measures of control being put forward. It appears certain, however, that no parasite is responsible, and therefore spraying or similar treatment is useless. Apparently the trouble is due to the conditions of growth, and probably in particular to climatic factors, such as cold nights following warm days, etc. Some of these factors, therefore, are likely to remain beyond our control. Where a tree produces a few overgrown apples, these are more liable to be affected than if the tree had borne a good crop of normal-sized fruit. Irregular growth caused by drought followed by heavy rainfall or irrigation often results in a bad attack. Those horticultural practices which tend to ensure even growth through the season and the maturing of a good crop of medium-sized fruit are, rather than any special measures, likely to remain the best safeguards against the disease.

McAlpine, who has been making an exhaustive study of the disease in Australia, finds that where the disease is liable to appear in storage on apples apparently quite sound when picked, "even with very susceptible varieties the development of bitter-pit was retarded by keeping them at an even temperature of 30° to 32° Fahr." He also recommends "that the apples should be picked . . . just when they have reached their full size and on the green side, and placed in cold storage without delay."

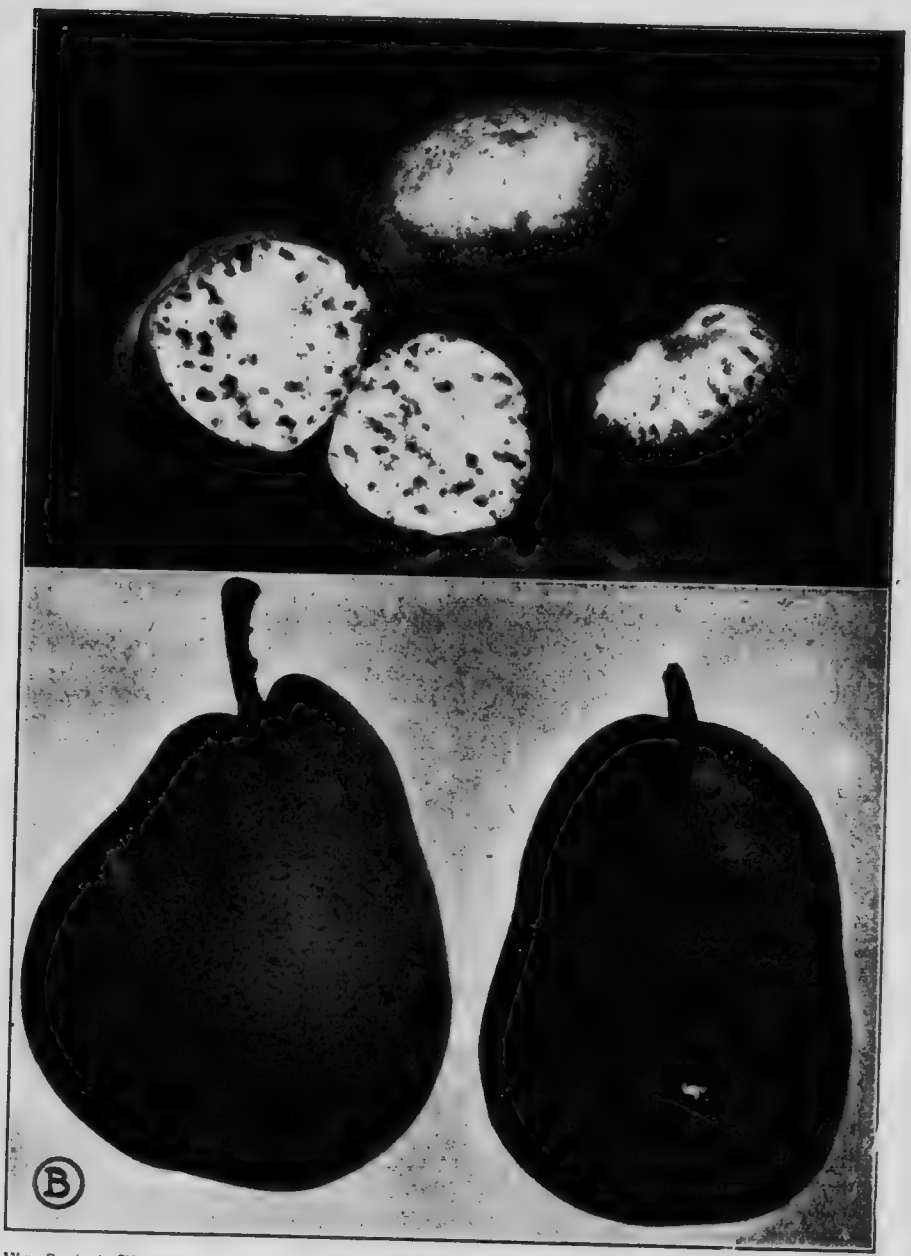

Fig. 3. (*a*.) Bitter-pit of apple. (*b*.) Frost-belting of pears, due to low temperatures when the fruit is very young.

WATER-CORE.

Like the last, this is a "physiological" disease, being the effect of a want of balance or a disturbance in the functions of the tree not brought about by the action of a parasite. It affects a wide range of varieties and is especially common in the Dry Belt. The tissue of a normal apple consists of minute cells filled with liquid and numerous air-spaces between them. These latter make the tissue opaque. If the pressure of sap becomes too great, liquid, instead of being confined to the cells themselves, is also forced into the spaces normally filled with air. Such tissue has a water-soaked and semi-transparent appearance. This is what has taken place in "water-core." The watery tissue is at first in small spots adjoining the vascular bundles or sap-channels, but later the core becomes filled with liquid. At this stage the hard lining membrane of the core will be found to be broken, and is often covered with a hairy growth. Affected fruit is generally exceptionally highly coloured. Fruit on the south and south-west sides of the tree is generally most affected. According to recent investigations, the development of the trouble is due mainly to two factors when the fruit is maturing: First, an excessive amount of sap in the tree, such as may occur after a period of heavy precipitation; and, secondly, a wide range between the day and night temperature over a period of time. During the warmth of the day transpiration from the leaves is active, but this is checked at night more rapidly than root-absorption is, with the result that the sap-pressure in the tree becomes so great that the sap is forced into the intercellular spaces. The main factors, therefore, are not under our control, except in so far as excessive sap-flow may be due to too much irrigation. It has been found, however, that if fruit is picked before the water-core has become too far advanced and placed in ordinary cellar—not cold—storage, the excess of sap will be reabsorbed and the fruit become normal. This does not apply to cases so far advanced that liquid has already appeared in the core. A recent authority cites a case where 10,000 boxes of water-cored apples grown in the Yakima District were removed from storage late in the season with a loss of only 0.3 per cent. Since the disease may be present in the apples from the south and south-west sides of a tree only, it would be well to determine if this is the case before commencing picking; and, if so, the two sets of apples should be kept separate.

BEAN.

ANTHRACNOSE (*Colletotrichum lindemuthianum*).

This disease attacks stems, leaves, and pods, but is most conspicuous on the last. It is commonly known as "pod-spot." On the leaves it appears as brown spots of varying shape and size; on the pods it forms sunken roundish spots of a dark-brown or black colour. Two or more spots may coalesce to form large irregular areas. Spores are produced in great numbers in spore-beds on the surface of the spots. The spores are cemented together by mucilage forming a minute pink mass. When wetted, e.g., by rain, the mucilage is dissolved and the spores set free. On the pod the fungus often makes its way into the underlying seeds, which become infected. Such seeds, if planted the following year, serve as the starting-point for the disease.

Control.—Use only seed gathered from pods free from the disease. Unless the selection is made from such pods no subsequent hand-picking of the seed will ensure that it is disease free, since seeds apparently sound may be sufficiently infected with the fungus to spread the disease if planted. If the disease appears in the crop, working amongst the plants when they are wet should be avoided, since it is then that the spores are freed. It should be possible to produce an unlimited quantity of clean seed in the Dry Belt.

Encyclopedia of Practical Hort' ture, Vol. I., page 496.

BEET.

LEAF-SPOT (*Cercospora beticola*).

Affects the leaves, appearing as small, circular brown spots, surrounded by a purplish zone. Later the centre of the spot falls out, leaving a hole. These spots may be so numerous as to seriously damage the leaf. It is rarely, however, serious enough to call for treatment. If it is, Bordeaux mixture may be used as a preventive.

BLACKBERRY.

CROWN-GALL.

This may form typical galls at or below the level of the ground. In such cases there is no treatment except grubbing out and burning the affected plants. Another form of the disease appears on the canes, the Snyder variety being especially susceptible. Irregular excrescences break out on them, several times the diameter of the cane in thickness and extending for several inches. A succession of these may occur along the cane, possibly resulting from internal spreading of the disease from centres of infection. Affected canes should be cut out and burned.

LEAF-SPOT (*Septoria rubi*).

Appears as small brownish spots on the leaves, which, however, are rarely numerous enough to cause serious injury or to call for treatment. Bordeaux mixture is an effective preventive if it is found necessary to take measures against it.

ANTHRACNOSE.

This is identical with anthracnose of the raspberry, *which see*.

CELERY.

LATE BLIGHT (*Septoria petroselini var. apii*).

This disease is quite serious in the Armstrong District, especially on low-lying land subject to floods, and in wet seasons. The disease on the leaves forms irregular spots, usually angular from being limited by the veins. They are yellowish to rusty brown in colour, with a darker border, and often run together to form large patches, so that the entire leaf may be killed. In the spots tiny jet-black points may be found. Each of these is a spore-chamber in which a large number of thread-like spores is produced. In addition to destroying the leaves of the growing plant, the fungus may continue its work in storage, producing extensive rotting of the leaves. It also attacks the "seeds," and is probably carried over from season to season in this way, seedlings from such seeds furnishing a primary infection from which the disease may spread in the seed-bed.

Control.—Collect as far as possible and burn refuse from a diseased crop. Select clean soil for a seed-bed. Spray with Bordeaux mixture as soon as the seedlings are up, and repeat weekly until transplanted. Continue in the field if necessary. It is best not to store attacked plants. If this is unavoidable the attacked leaves should be first stripped off. The cellar must be cool and well ventilated.

EARLY BLIGHT (*Cercospora apii*).

Much like the last in general appearance, but the fungus shows different characteristics under a lens. Not so common and destructive with us as the last, and not causing the storage rot. The treatment given above will also control this disease.

HEART-ROT.

The inner parts of the blanched plant become affected with a soft pale-brown rot. Apparently similar to the bacterial soft-rot which attacks so many vegetables. Due partly to excess of moisture. Plants should not be earthed up when wet. If boards are used for blanching, an interval of several days should be allowed to elapse from first putting them up until they are finally closed up. This allows some of the excess of moisture to escape.

"RUST."

There is a true fungus-rust which attacks the leaves, but this has not been noticed here. What commonly goes by this name is a rusty or orange-red spotting of the outer leaf-stalks where they are in contact with the soil. Probably due to local infection by soil organisms, and preventible by using boards for blanching.

CHERRY.

BROWN-ROT.

This is chiefly destructive to the sweet cherry. This is chiefly grown, however, in the Dry Belt, where the disease is not serious, if present at all. In the wet climate of the Lower Mainland, in seasons which favour the disease, it is often not possible to control it profitably, especially as the conditions which contribute to its severity also cause other damage, such as the splitting of the fruit. An account of the disease and its control will be found under "Plum."

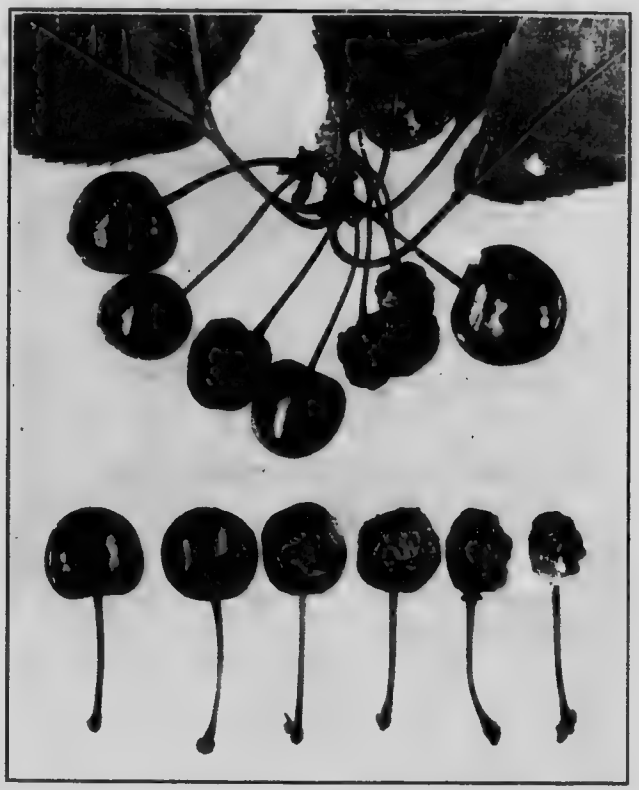

Fig. 4. Brown-rot on sweet cherries. The lower figure shows a series of different stages in the development of the disease.

GUMMOSIS.

The cherry, in common with other stone-fruits, is very liable to suffer from this, the sweet cherry especially so. The cell-walls break down and are changed into gum, which exudes and dries in masses on the bark. Often this follows wounds or frost-injury, but it may be spontaneous, as in wet seasons or situations, or where growth has been forced. In the case of gumming from wounds, where these are of any size, they should be cleaned out and disinfected. The bacterial gummosis due to a specific organism, and which is so destructive in Oregon, has not been observed here.

SHOT-HOLE (*Cylindrosporium padi*).

This attacks the leaves, forming first reddish-brown spots, often with a purplish zone around them. In most cases the centres of these spots ultimately fall out, giving a "shot-hole" effect. Spores are produced on the spots and spread the disease. In severe attacks most of the leaf-tissue may be destroyed and the leaf itself falls prematurely. This weakens the tree, and if severe attacks occur two or three years in succession the effects may be very serious.

Fig. 5. Shot-hole of cherry. Some of the attacked spots have fallen out; others are about to do so.

Control.—Spray with Bordeaux mixture, 2-2-40 or 2-3-40, after the fruit is set, again immediately after it is picked, and three or four weeks later if required. Owing to the sensitiveness of cherry-foliage to chemicals, stronger preparations are not safe, as they may cause serious burning of the foliage.

BLACK-KNOT (*Plowrightia morbosa*).

Wild choke-cherries in the Okanagan are much attacked by a fungus apparently identical with the common black-knot of the East, but so far no case has been recorded on the cultivated cherry or plum.

CLOVER.

DODDERS (*Cuscuta sp.*).

These are the only parasites of the clover-plant which it is necessary to mention here. There are several species attacking clovers and alfalfa, but the only cases observed here, as yet, have been on clover, and so far as actually examined by the writer are due to *C. epithymum*. Other species of dodder are occasionally reported on various garden-plants, but are not likely to become troublesome.

Dodders are flowering plants related to the morning-glory or bindweed, and have the same twining habit. They do not, however, contain the green colouring-matter (chlorophyll) so characteristic of higher plants, and cannot, therefore, elaborate their own food-supply from the simple raw materials of the air and soil. The leaves have become reduced to mere scales on the stem, while the only roots produced are the small "sucking-roots" (haustoria) which are given off from the dodder-stem at the points where it is in close contact with the stem of the plant to which it clings. These haustoria penetrate into the tissues of the host-plant and absorb its juices, on

which the dodder-plant depends entirely for its nourishment. It is therefore a total parasite, and on this account causes serious injury to, and ultimately the death of, its host. The pest is always introduced by its seed being present in the seed of the clover or alfalfa sown. The seeds germinate, and the seedling attaches itself to a near-by clover-plant. Once established, the dodder-vine branches profusely and spreads over neighbouring plants until a whole patch is infested. In the earlier stages of infestation the pest is generally distributed over the field in such patches which are visible at a distance from their yellowish colour, due to the mass of yellow dodder-vines, and the death or debility of the otherwise green clover. Large numbers of clusters of small pinkish blossoms are produced, each forming one to four seeds. In the case of clover grown for seed, these are finally threshed out and mixed with the clover-seed. If left until ripe they fall to the ground and germinate next year, giving rise to a new infestation. Clover-dodder is usually an annual, although it has been shown to be perennial in certain cases.

Control.—Infection comes through sowing impure seed; every care, therefore, should be taken to avoid such seed. Seed should be purchased under a guarantee of freedom from dodder, and a sample should be sent to the Seed Branch, Dominion Department of Agriculture, Ottawa, or to the Western Office of this Branch at Calgary. An examination will be made and a report furnished free of charge.

Where infestation has occurred, treatment will depend on its extent. If it occurs in patches, these should be cut close, and well beyond the edge of the patch, the material mixed with straw or saturated with coal-oil and burned on the spot. Where the infestation is general, the field should be ploughed up and not seeded again to clover or alfalfa for two or three years.

CORN.

SMUT (*Ustilago zeæ*).

This occurs in the Coast and Island sections, but the writer has not seen it in the Interior. Any part of the plant above ground may be attacked, and infection may take place at any time if the tissues are still sufficiently tender. Infection results in the formation of a tumour, varying in size according to the part attacked, but often as big as a man's fist. Inside this enormous numbers of black spores are produced. The tumour is at first covered with a shining white membrane, which later breaks, allowing the spores to be scattered.

Control.—Cut out and burn the tumours before they break and scatter the spores. Do not in any case throw them where they will find their way on to the manure-pile, as this gives the spores an opportunity to multiply further. Seed-treatment as used against smuts of oats and wheat is useless against this disease.

GOOSEBERRY.

POWDERY MILDEW (*Sphærotheca mors-uvæ*).

This is the most serious disease of the gooseberry. Many varieties of English gooseberries are so susceptible that they cannot be grown profitably where conditions favour the disease. The fungus is a typical powdery mildew, in that it is of superficial habit, and reproduces in the usual way, but it is more resistant to spraying and more difficult to control than most powdery mildews. It first appears on the leaves as greyish-white patches of mycelium, and later on the fruit. Spores are produced in large numbers from this mycelium, and new infections take place until the young shoots and berries may become entirely enveloped in mycelium. As this gets older it changes from white or grey to yellowish and finally brown. The growth of the shoot is stunted and the leaves remain small. The fruit may be directly injured, becoming misformed or cracked, but the chief damage is due to the unsightly appearance of attacked berries which renders them unsaleable. Small black fruiting-bodies ultimately appear in the mycelium, and these produce another form of spore and carry the fungus over the winter.

Control.—Spray with lime-sulphur solution diluted 1 to 9 before the buds break. Repeat with a dilution of 1 to 25 or 30, after the fruit is set, and at intervals afterwards, depending on weather conditions. When the lime-sulphur becomes objectionable through forming a deposit on the maturing fruit, liver of sulphur (potassium sulphide), ½ oz. to a gallon of water, may be substituted. This does not adhere as well, but leaves no deposit. Badly diseased shoots should be pruned out and burned.

The same disease also attacks the currant, but is rarely serious on this host.

HOLLYHOCK.

RUST (*Puccinia malvacearum*).

This is generally distributed on both hollyhocks and the wild round-leaved mallow, being often very serious on the former. It is one of the comparatively few fungus-diseases conspicuously abundant in the Dry Belt. The disease shows first as orange spots on the part attacked. Later these spots bear large, firm, dark-brown masses of spores. On the leaves these spore-masses (sori) are on the lower side. They may be so numerous that the leaves are practically destroyed and the plant severely injured. The leaf-stalks, stems, calyx, and fruit may also be attacked.

Control.—Destroy wild mallows in immediate vicinity. Burn remains of attacked plants. Spraying with Bordeaux mixture helps to prevent the disease, but renders ornamental plants somewhat unsightly.

OAT.

LOOSE SMUT (*Ustilago avenæ*).

This disease is almost universally present where oats are grown. The chaff and kernel are destroyed by the fungus and replaced by a black powder of fungus-spores, hence the name "smut." These are later blown away until at harvest-time nothing but bare stalks and the remnants of some of the chaff are left. Although the disease only manifests itself when the ear is out of the sheath, the fungus has been present in the plant since the seedling came above ground. When the smut-spores are scattered they are carried by the wind to the ears of neighbouring healthy plants which are developing kernels. Some of these spores will find their way into the crevices about the hulls, and will remain there until after the seed is threshed. Should such seed be sown the next year, these spores germinate at the same time as the seed, and produce a second kind of spore. These in turn germinate, each producing a delicate fungus-thread (germ-tube) which can enter the oat seedling through the cotyledon or first leaf, which encloses the other leaves as the seedling comes through the ground. Once the fungus is established in the plant it remains near the growing-point. Since the branches formed in stooling also arise at this point, these generally become invaded by the fungus. Hence it usually happens that when a plant later shows the smut, every ear on the plant shows it. The fungus does not apparently injure the plant until flowering-time, being confined to the region near the tip of the shoot. When the ear is forming, however, large quantities of food substances are being conducted there to nourish the flowers and developing grain, and this seems to stimulate the fungus into great activity. It extends rapidly at the expense of the food substances and the tissues of the ear, producing enormous numbers of black spores which form the "smut" with which we started.

Control.—Infection only takes place during the earliest stages of the seedling, and practically always from spores adhering to the seed when sown. By treating the seed with certain substances these spores can be killed without injuring the seed, which will then produce a disease-free crop. The best substance for this purpose is a 40-per-cent. solution of formaldehyde, diluted at the rate of 1 lb. to 40 gallons of water. The seed is spread out in a layer on a smooth, hard floor or canvas, and the mixture sprinkled over it with a watering-pot, or in any other way that may be convenient, the seed being at the same time shovelled over to secure uniform moistening. It should then be piled and covered with bags, canvas, or other material to keep in the fumes of the formalin and left six to twelve hours (usually overnight).

It is then spread out in a thin layer and shovelled over at intervals until as dry as required. It may be sown as soon as dry enough to run through the drill, about 20 per cent. more seed being allowed in this case on account of its swollen condition; or it may be completely dried and stored. In this case, however, there is more danger of reinfection, and injury to the germinating power is more likely to occur if kept for any length of time. Sacks, canvas, drill, and, in fact, everything that is to touch the treated grain should be similarly disinfected, otherwise there is danger of smut-spores being again mixed with the grain and the work being spoiled. If the grain is sown before completely dry there is less danger of this. One gallon of the liquid will treat approximately 1½ bushels of grain.

Another method is to immerse the grain, in sacks of coarse material not more than half-full, in the same strength of liquid, moving the sack up and down to ensure thorough wetting of the seed. After being allowed to drain for a few moments the contents may be piled and treated as above, or the grain may be left in the sacks the same length of time, then spread out and dried. Bluestone, which is often used against wheat-smut, should not be used for oats, as it is liable to injure the germinating power of the grain very seriously.

Covered Smut (*Ustilago levis*).

This differs chiefly in the chaff of the ear not being so extensively destroyed, the spores thus remaining enclosed for a longer period. There are also minute differences in the spores themselves. It is controlled, however, in precisely the same way as the last.

ONION.

Downy Mildew (*Peronospora schleideni*).

Reported only from the Coast sections. In the earlier stages the disease may be recognized by the presence of a purplish velvety appearance on the attacked leaves, best seen when the dew is on them. This appearance is the result of the formation of numerous spore-bearing threads (conidiophores) of the fungus, which are pushed out through the pores of the leaf. Such leaves rapidly turn yellow, fall down, and decay. The spores are carried by the air to other leaves and other plants, and rapidly produce new infections if the weather is warm and moist. New leaves are put out to take the place of those destroyed, but these also may become attacked. In any case the growth of the bulb is checked, and its size reduced to an extent depending on the severity of the attack. Inside the tissues of the attacked leaves resting spores are produced which persist through the winter in the remains of such leaves, thus carrying the fungus over the winter and furnishing a means of infection for the onion-crop the following spring.

Control.—Destroy the refuse from an attacked crop as completely as possible. Do not plant onions for two or more years on land where there has been an epidemic of the disease. Spray with Bordeaux mixture often enough to protect the new growth. The date of the first application will depend on the time when the disease has been observed to appear. Spraying must be done sufficiently before this to protect against the first infection, rather than after the disease has been noticed. Owing to the smoothness and waxy covering of the onion-leaf, ordinary Bordeaux mixture runs off, and it is necessary to use the resin Bordeaux in order to secure its adhesion.

PEACH.

Brown-rot.

In most peach-growing districts this is a very serious disease. In British Columbia, however, peaches are only grown commercially in the Lower Okanagan District, where the climate is dry enough to render this disease of little importance. Where the disease occurs much loss may take place through rotting during transportation. With us, such cases of rotting during transit as have been examined have been due mainly to such mould-fungi as *Rhizopus nigricans* and *Penicillium sp.*

Fig. 6. Peach-leaf curl. Note the characteristic deformation of the leaves. The two twigs at the extreme right have been killed as the result of an attack; the other two are injured but recovering.

LEAF-CURL (*Exoascus deformans*).

This disease appears to be present wherever peaches are grown. The most characteristic symptom is indicated in the name "leaf-curl." Attacked leaves show an excessive growth in the soft tissues between the veins, causing a pocket-like bulging towards the upper surface. If badly attacked the leaf also curls upon itself. The affected areas have a blenched yellowish or a red colour instead of the normal green, and finally become covered with a greyish bloom due to the formation of a minute velvety layer of spore-sacs. In addition to the leaves, young shoots may be attacked, being thicker and shorter than healthy ones. It was formerly supposed that the fungus was carried over from season to season largely as perennial mycelium in such shoots. We now know, however, that this method of over-wintering is only responsible for a very small proportion of the spring infection. Infection takes place almost, if not entirely, while the resting buds are unfolding in the spring. Where an attack has been severe enough to cause extensive defoliation the new leaves that are put out will remain quite healthy. The spores that cause infection are apparently lodged on the bud-scales, and as soon as these are forced apart sufficiently to allow of the spores being washed against the young leaves inside by rain, infection may take place. Cold, wet weather at this time greatly increases the chances of an epidemic, probably because it kee the leaves from outgrowing the susceptible stage as rapidly as would otherwise be the case. Accurate data on the relative susceptibility of different varieties are difficult to procure, but it seems to be generally agreed that the Elberta is the most susceptible.

Control.—It has been found that one spraying with any good fungicide will almost entirely control this disease. It is essential, however, that the spraying be thorough, otherwise the spores protected under the edges or amongst the hairs of the bud-scales will not be reached. It is also necessary that the application be made at the right time. If the bud-scales have opened sufficiently to allow of spores being washed by rain against the enclosed young leaves there is danger of infection taking place. Once any green is showing it is too late to prevent some infection. So far as the leaf-curl itself is concerned, good results are obtained if the spraying is concluded a week or two before the buds swell. In most cases, however, the grower has also to combat the peach-worm, and this makes it desirable to modify the spraying so as to make it effective, if possible, for both purposes. Lime-sulphur, winter strength, put on so that the application is completed at, or just before, the time the buds begin to swell, will not only control the leaf-curl, but will destroy many of the over-wintering larvæ of the peach-worm.

POWDERY MILDEW (*Sphærotheca pannosa*).

This forms a white mouldy growth over the young twigs, leaves, and fruit. It usually occurs as spots and patches, but may cover the entire surface. Leaves of affected twigs are pale, narrow, and distorted, giving the twig a ragged appearance. The disease was very serious in the Southern Okanagan last year, a large proportion of the fruit being affected. Fruit with large mildew-spots on it is unsightly and hence unsaleable, but a more serious consequence lies in the fact that rot organisms enter very readily through the affected spots. Hence even slightly affected fruit does not stand up well in transit and such fruit should not be shipped.

Control.—Owing to the sensitive nature of the foliage of the peach, the summer sprays, such as lime-sulphur solution, used on other orchard trees cannot be employed. Where thorough spraying for leaf-curl is carried out, however, mildew is often lessened. Dusting the trees with flowers of sulphur when the dew is on, or after rain, at intervals of ten to fourteen days will reduce it, or self-boiled lime-sulphur may be used. It is claimed for Atomic Sulphur that it is very effective against this disease; 4 to 5 lb. to 40 gallons of water is the strength recommended, to be applied soon after the petals fall, or, at any rate, as soon as the first indications of mildew are observed. Whatever substance is used, special care should be taken to cover the young fruit.

Fig. 7. Powdery mildew on peach. Note the dwarfed condition of the foliage.

PEAR.

BACTERIAL OR FIRE BLIGHT. (*See* under "Apple.")

This disease is more severe and more difficult to control in most varieties of pears than in any but the most susceptible varieties of apples. It is necessary, therefore, to exercise the greatest vigilance where pears are concerned, and to keep at the work continuously as long as any blight remains.

SCAB (*Venturia pyrina*).

This disease is very similar in its nature to apple-scab, *which see*. The two fungi, however, although very closely related, are distinct, all attempts to produce pear-scab with the apple-scab fungus and vice versa having been unsuccessful.

Control.—As for apple-scab. Twig-infections are, however, more liable to occur, and the summer spores are more likely to retain their vitality over the winter. For these reasons the spraying with winter-strength lime-sulphur just before the buds burst is generally of more value than in the case of apple-scab.

PLUM.

BROWN-ROT (*Sclerotinia fructigena*).

This disease attacks all varieties of stone-fruits and is very destructive where the climate is at all wet during the summer months. The disease is best known on the fruit, and it is chiefly as a fruit-rot that it is of economic importance. Infections first show as circular brown spots gradually extending in size until the entire fruit is affected. The affected areas do not shrivel or become sunken for some time. Evidence of the nature of the disease is further afforded by the appearance of small

fungus-cushions of a brownish colour on the affected areas. These cushions, or tufts, are composed of spore-producing threads (conidiophores) of the causal fungus, from which summer spores are produced in great numbers and scattered by the wind. As the fruit approaches maturity it becomes more susceptible, and decay during transportation is one of the most serious consequences of the presence of the disease. Fruit apparently sound and free from injury of any kind when packed, but with the spores adhering to the surface, may rot extensively in the course of two or three days. Rotted fruits gradually shrivel up, forming the so-called "mummies," and these form the source of infection in the succeeding spring. The hybernating fungus may behave in two ways, according to conditions. In the case of mummies left hanging on the tree the fungus produces spore-bearing cushions similar to those formed during the earlier stages of the rot. These spores may disseminate the disease exactly as in the preceding summer. Where the mummies have fallen to the ground and become lightly covered with earth, or kept moist amongst grass or

Fig. 8. Brown-rot in plums.

a cover-crop, the fungus may produce a totally different kind of spore-bearing structure. In this case a delicate fleshy cup of a brown colour, ¼ to ½ inch in diameter, is pushed above ground on a slender stalk. The inner surface of this cup is lined with minute sacs, each of which when ripe contains eight spores. These spores are liberated about blossoming-time.

In addition to the fruit, the blossoms and twigs may be blighted, but in the latter case the infection has in all probability come about through the previous infection of the flower or fruit working back through the pedicels or flower-stalks.

Control.—Since the "mummies" form the means of carrying the fungus over the winter, it is essential that these be knocked off the tree, if they have not fallen naturally, collected and destroyed, unless they can be ploughed in deeply enough in the spring to prevent them from becoming sources of infection. They would have

to be buried at this time at least 8 inches. The satisfactory disposal of these mummies, especially in the case of large cherry-trees, is one of the main difficulties in the control of the disease. Fruits should be thinned so that no two touch each other, since enough moisture may be held at such points of contact to enable spores of the fungus to germinate and produce infection. Trees should be thoroughly sprayed with winter-strength lime-sulphur before the buds break. Later sprayings will be necessary for protection of the fruit, but the nature of the spray material and the times of application will depend partly on the susceptibility of the tree to spray-injury, and partly on the time when the fruit is sufficiently advanced to be disfigured by the presence of spray material. In the case of peaches, and some plums, which are particularly sensitive to this form of injury, it is generally found necessary to use the self-boiled lime-sulphur, although it is claimed for atomic sulphur that it is both safe and effective. For most cherries 2-3-40 Bordeaux mixture is safest, while for some plums, including probably prunes, 4-4-40 strength might be used. The first of these sprayings should be given two or three weeks after the petals fall, and another one about a month before the fruit is expected to ripen. An intermediate spraying may also be necessary.

POTATO.

Farmers' Circular No. 4 of the Division of Botany, Dominion Department of Agriculture, entitled "Potato-diseases transmitted by the Use of Unsound Seed-potatoes," gives excellent coloured illustrations of various tuber-diseases, as well as recommendations for their control. It should be in the hands of every grower. It may be obtained free of charge by writing to the Publications Branch, Department of Agriculture, Ottawa. Letters of application so addressed need not be stamped.

EARLY BLIGHT (*Macrosporium solani*).

This disease attacks the leaves only. It appears as circular or elliptical, dark-brown or black spots, which often show a concentric zoning. Where these spots are sufficiently numerous the whole leaf may finally present a scorched appearance resembling a bad case of "tip-burn." Infection often follows minute injuries such as those caused by flea-beetles, but these are not necessary for infection. Dry seasons and climates usually favour the disease, although it can be quite bad under fairly moist conditions. The name "early" blight merely implies that it is noticeable earlier in the season than the "late" blight, and not that it is restricted to the early part of the season.

Control.—Spray with Bordeaux mixture, 4-4-40, beginning when the plants are 6 inches high or less. The disease, however, is only occasionally serious enough to warrant special measures.

LATE BLIGHT (*Phytophthora infestans*).

This is a very serious disease in the moister sections of the Province, especially on the Lower Mainland. It is first noticed on the leaves, where purplish or brownish-black, irregular spots appear which rapidly extend if conditions are favourable. They commonly occur first on the tip or edges of the leaf. Often a mouldy growth may be observed around the margins of these spots on the under-side of the leaf. This is composed of spore-bearing threads pushed out through the breathing-pores (stomata) of the leaf. If the conditions are right—that is, if the weather is moist and moderately warm—the disease may spread with great rapidity, so that the tops of an entire field may be completely destroyed in a few days. A peculiar unpleasant odour is given off from the diseased tops. The rapidity with which the disease may spread is largely due to the peculiar character of the spores produced. These are at first much like the summer spores (conidia) of many other fungi, and are scattered easily by the wind and rain. Their usual behaviour, however, is different. Should one fall on a moist spot, such as the film of water on a leaf after rain, and

be kept for a time under these conditions, the contents of the spore divide up into a number of smaller units. These soon come out and are capable of swimming about actively in the water on their own account. Hence they are termed *zoospores* or "animal" spores. Very soon each zoospore comes to rest, germinates, and produces an infection. In this way the number of infections may be very greatly increased, since one spore of the first kind may give rise to as many as thirty of the second, the whole procedure from the first spore to the new infection only occupying a few hours. However, under certain conditions the first type of spore may germinate directly and produce an infection, without any formation of active spores.

Although the destruction of the tops may in itself be serious by preventing the proper maturation of the tubers, it is not the worst form of the disease, since the tubers are themselves attacked. On the mature tuber the affected areas appear of a dull leaden colour and somewhat sunken. On cutting, brown diseased tissue is seen to underlie them. This may be confined to a thin superficial layer or may

Fig. 9. Tuber infected with the fungus of late blight. Note the discoloured areas under the skin, corresponding with the depressed discoloured areas visible on the surface.

involve most or all of the tuber. This form of the disease is commonly spoken of as a "dry rot." Although the dry rot produced by the fungus may work much injury, it is usually more important indirectly, since it permits the entrance of other organisms, especially bacteria, which rapidly destroy the tuber, producing a "wet rot." This may take place in the soil if this is wet and heavy, or in storage. The tubers apparently become affected, in the first instance, by spores washed against them by the rain. Exposed tubers or those near the surface are, therefore, especially likely to show the disease. The manner in which the first infections of the growing plant come about has been the subject of much discussion. Apparently the fungus remains alive in many of the infected tubers, and, if such be planted, becomes active, producing conidia either on the seed-tubers themselves or on the sprouts from them. These conidia, being subsequently carried to the leaves, give rise to the early infections from which an epidemic may later develop.

Infection of the tubers may apparently take place at any time if spores of the fungus come in contact with them under conditions of sufficient moisture and warmth, but it is facilitated by injuries which break the skin. Much infection may take place during digging-time if the tops have not been dead long enough to ensure the death of the spores also. Where the tubers have been piled in the field, and covered with infected tops still producing spores, every tuber may become infected. The disease may also spread extensively in storage if the tubers are kept too warm and moist.

Control.—Avoid the use of infected tubers for seed, no matter how slight the infection may appear to be. Where the disease has been at all severe, do not dig until the tops have been dead at least a week. Cellars or other storage-places should be kept cool, dry, and well ventilated. The most important measure of protection consists in spraying the growing plants at proper intervals. Since the disease is carried to the tuber from the tops, it follows that the checking of the disease above ground will protect the tubers. The most satisfactory spray is Bordeaux mixture, lime-sulphur having been found injurious. For earlier sprayings a strength of 4-4-40 may be used; for later ones, when the disease is liable to become epidemic, 6-6-40 is better. No definite data have been collected here as to the usual time when the first infections are noticed, but generally, as far as this disease alone is concerned, if the first application is made about the blossoming-time of later varieties adequate protection will be afforded. The number of sprayings to be given will be governed by conditions. In wet seasons, when the disease is liable to be severe, spraying every week or ten days may be necessary to control it. Usually about three applications are sufficient. Since the disease varies greatly in severity from year to year, being very bad one year and perhaps almost absent the next, it was at one time questioned whether spraying each year as a safeguard would be profitable, taking one year with another. Extensive experiments have settled this point conclusively, since it has been found that properly made Bordeaux mixture has a beneficial effect on the foliage, enabling it to keep green longer and do more work. The result is an increased yield, so that even if no blight appears the cost of spraying is repaid in whole or part. In seasons when the disease is bad, spraying may make all the difference between a good yield of marketable tubers and a total crop-failure.

WART-DISEASE (*Chrysophlyctis endobiotica*).

Also known by the names of potato-canker and black-scab. This disease is not known to exist in Canada at the present time, and as a complete embargo is in force against the importation of potatoes from any country where it is known to occur, we have grounds for hoping that we may remain free from it. The disease occurs to a considerable extent in Great Britain and Ireland, and these countries are, therefore, included in the embargo. The attempt occasionally made to bring in small quantities of seed-potatoes from these countries in the mails is illegal, and punishable with a heavy fine. As the disease is a very serious one, it is desirable that growers should be able to recognize it, in order that they may report its presence immediately, should it at any time be discovered. Circular No. 4 of the Dominion Department of Agriculture, mentioned at the head of this article, gives a very good illustration of an affected tuber. Anything suspiciously like this should be sent to the Plant Pathologist for examination.

COMMON SCAB (*Actinomyces chromogenus*).

This disease is so common that a description is hardly necessary here. The most important of its characteristics will be pointed out in the consideration of the next disease—powdery scab. Common scab attacks the tubers only, and varies from a rough corky spot, usually distinctly raised above the surface of the tuber, to an irregular pit. Only one or two of these spots or pits may be present on a tuber, or they may be so numerous that the entire surface is disfigured with them. The chief injury lies in the unsightly nature of the scabby spots, which is objectionable to

the consumer, and consequently reduces the market value. There is also much greater wastage in preparing such potatoes for the table. Severe attacks also cause a loss in the yield, although the amount of this is difficult to estimate. The scab-spots, especially in the "pit" form, afford an opportunity for the entrance of various rot-producing fungi and bacteria. This is at times particularly noticeable in fields which have been excessively irrigated. In such cases, if scab is also present, much rot may be found starting at the scab-spots.

The disease is due primarily to a bacterial organism, which invades the superficial cells of the developing tuber. As a result, the corky tissue which forms the normal skin becomes excessively and abnormally thickened at this point, giving rise to a scab-spot. From recent investigation it appears probable that this organism is naturally widely distributed in the soil and able to produce the disease if conditions are favourable. Amongst the conditions predisposing to the disease, an alkaline or insufficiently acid condition of the soil and heavy dressings of barnyard manure are probably at the same time the most important and the easiest to control.

Control.—Avoid the use of alkaline fertilizers, such as lime, shell-marl, wood-ashes, etc., on land that is shortly to be planted to potatoes. The use of acid fertilizers, such as superphosphate, is beneficial. Good results have been claimed from ploughing-in a green crop such as rye, but this is not always successful; sometimes, indeed, it may have the reverse effect. Heavy applications of barnyard manure should not be made to the potato-crop, but, if necessary, given at some other point in the rotation. Seed should not be planted in contact with the manure. Disinfecting the seed before planting has been extensively practised, often with the best results, sometimes without much benefit. Much depends upon the degree to which the soil has become infected, and the care with which the disinfection is carried out. The purpose of it is to destroy the scab organisms on the tubers or in the scab-spots, and thus remove the source of infection. Obviously this would not be of much value if the soil is full of the germs. It may be argued that if the scab organism is naturally present in soils seed-treatment would be useless, but this does not necessarily follow. Those organisms coming directly from an attacked potato are likely to be much more virulent, and would be concentrated at the spot where the new tubers are being formed, thus giving every opportunity for infection. As a matter of general precaution, not against scab merely, but against other diseases also, tubers apparently free from disease should be selected for seed purposes, and should be disinfected to destroy germs of disease that may be adhering to the surface. Either of the following methods may be used:—

(1.) *Formaldehyde (Formalin).*—This when purchased should be guaranteed a 40-per-cent. solution; 1 lb. of this is added to 30 gallons of water and the tubers soaked for two hours in it. They are then taken out, drained, and spread out to dry on a clean floor, or on sacks or canvas. These should have also been previously disinfected by being dipped or washed down, as the case may be, with the same or, preferably, a stronger solution of the same substance. The advantage of formaldehyde is that, although irritating to the skin, it is not otherwise poisonous, does not corrode metals, and treated potatoes may, if they should not be planted, still be used for table purposes or stock-feed. A certain portion of the liquid is necessarily lost in the treatment of each lot of potatoes, but that which is left does not become weaker and may be used repeatedly.

(2.) *Corrosive Sublimate (Mercuric Chloride).*—A solution of 1 part in 1,000 of water is used. For small quantities it is most convenient to buy the prepared tablets, procurable at any drug-store, and which are each of known weight. Usually they are so prepared that one to a pint of water gives a 1 to 1,000 strength. For larger quantities the chemical may be bought in bulk and used at the rate of 4 oz. to 25 gallons. Corrosive sublimate is a much more powerful disinfectant than formaldehyde, but is a violent poison if taken internally, and must be used and disposed of with great care. The solution also corrodes metals and must therefore be prepared in a wooden or earthenware vessel. Treated potatoes retain enough of

the poison to make it dangerous to use them for food. The solution becomes weaker with use, and should not be used more than three or four times. The same precautions must be observed to prevent subsequent infection as in the last case; i.e., the floor, etc., should be disinfected. Planters, containers, and other implements which are to come in contact with the potatoes should be similarly disinfected. After treatment the tubers are cut and handled in the usual way.

Many treatments have been tried for soil that is scab-infested, but beyond what has already been mentioned, little of practical value has so far been found.

POWDERY SCAB (*Spongospora subterranea*).

This disease was first noticed in Canada about three years ago, and was found, subsequently, in various areas of the Maritime Provinces and Quebec. As a consequence a complete embargo against Canadian potatoes was put in force by the United States at the beginning of 1914. In the early summer of 1915, owing to a shortage of potatoes in the Pacific States, the embargo was temporarily raised to allow of the shipment of potatoes from British Columbia. The discovery, however, of powdery scab in a consignment sent to Seattle caused the embargo to be replaced. Since January 1st, 1916, the embargo has been again raised. During the past season a careful survey has been made with a view to ascertaining the extent to which the disease may be present in the Province. So far, it has been discovered only in the Sea Island District and the immediately adjacent Delta country. None of the disease has been found in the Interior, although a careful inspection of the Ashcroft area was made.

Superficially, this disease much resembles common scab, but there are certain differences which enable a person familiar with them to distinguish most cases at sight. A certain number of cases, however, are met with in which microscopic examination is necessary, and suspected cases should be sent to the Plant Pathologist for examination.

Compared with common scab, the spots or pustules of powdery scab are, in general, smaller and with a more even outline. Even where they are numerous they retain their individuality better, and have not the same tendency to run together into large affected areas in which the individual spots cannot be recognized. The surface is smooth when the spot is young, consisting, in fact, of the ordinary skin of the tuber instead of the rough, irregularly thickened, corky tissue of common scab. On breaking this skin the pustule is found to be filled with a brownish or greenish powder, mixed with a certain amount of dried-up tissue. If this is rubbed away, another distinct skin is generally found beneath, marking off the spot from the sound flesh of the tuber. In the case of common scab there is nothing comparable to this, the rough corky tissue lying directly on the sound flesh. The powdery mass which has given the name to the disease is composed of spore-balls, each one of which is a mass of minute spores adhering firmly together. Many of these are set free in the soil before or at digging-time, while they may be very readily distributed on implements, bags, or the skin of apparently healthy and desirable tubers. In this way the disease is spread. Once introduced into the soil it is probable that potatoes planted there within a period of several years will be liable to the disease. As in the case of common scab, the chief injury lies in the unsightly appearance of affected tubers. There is, however, a much greater tendency for affected tubers to shrivel in storage. In bad cases, especially when the potatoes have been grown year after year on the same wet, heavy soil, the injury may be very great, although it must be admitted that under such circumstances good yields can hardly be expected in any case. At the present time the disease in British Columbia is, on the whole, of a very mild type, a careful inspection of a 5-acre field at digging-time often resulting only in the finding of two or three slightly affected tubers. With proper precautions, therefore, on the part of the growers, there is every reason to hope that the spread of the disease may be checked.

Fig. 10. (1.) Tuber affected with common scab. (2.) Tuber showing a mild attack of powdery scab. The pustules are mostly small and isolated. (3.) A more serious form of the disease. The scabs are confluent and cover a large proportion of the surface. (4.) Shows different appearances presented by the pustules. Those marked + have the covering membrane still intact; in those marked ‖ the membrane has just been broken, while at O the mass of spore-balls is becoming broken up and the spore-balls scattered. (5.) A much-deformed tuber showing a very bad, but fortunately rare, form of the disease. (*From original photographs by H. T. Gussow.*)

Control.—From what has been said, it will be seen that the disease is spread mainly by planting seed which is infected, or which has been in contact with infected tubers, bags, implements, etc. In purchasing seed from the districts mentioned above, a guarantee should be required that no powdery scab has been found in the field, or, still better, on the farm where they were grown. Seed-disinfection (*see* under "Common Scab") should always be practised. This will not render apparently sound tubers from an affected crop safe to use for seed, as the disease may possibly be present in such tubers in sufficient amount to affect the crop raised from them and to infect the soil, and yet be in a form not reached by seed-treatment. It will, however, destroy spores on the surface, and therefore remove the risk of the disease being introduced on healthy tubers which have been in contact with containers or implements contaminated with spores. Corrosive sublimate should be used for this purpose in preference to formaldehyde. Sound tubers from an infected crop may be disposed of for consumption if each container is plainly marked "Table potatoes only—not to be used for seed." Affected tubers, or tubers from an affected crop, should be cooked before being fed to stock, otherwise the manure may be contaminated and the disease be spread to other fields. The same applies to parings and other refuse from an attacked crop. These should not be thrown on the manure-pile, but boiled or burned. Cellars, bins, bags, etc., where diseased potatoes have been should be disinfected with bluestone (copper sulphate), 1 lb. to 5 gallons, or formaldehyde, 1 lb. to 1 gallon of water. Infected soil should not be planted to potatoes again for five years. Farmers' Circular No. 5 of the Division of Botany, Dominion Department of Agriculture, Ottawa, deals more fully with this disease than is possible here, and should be written for by those interested. (*See* note at head of this article.)

RHIZOCTONIA.

Tubers are very commonly found with what appear to be bits of hardened soil adhering to them. Careful examination shows, however, that these masses of foreign matter adhere very firmly, and on being moistened take on a black colour. In size they may vary from that of a pin's head or less to ¼ inch in diameter, and may be very numerous. They may be detached with the finger-nail and the skin of the tuber underneath will be found quite sound. These bodies (named *sclerotia*) are compact masses of the resting mycelium of a fungus commonly known as *Rhizoctonia*. They do not cause any disease of the tuber, except perhaps in rare instances, but they injure its appearance. If such tubers are planted, however, the resting mycelium in the sclerotium gives rise to an active form which may work much injury in the growing crop. In many cases the sprouts are killed before they get above ground, this being one cause of potato failures. Later in the season various symptoms may appear. Some stems may die prematurely, and on examination there will be found at the base of the stem, usually at the ground-line or extending either way from this, dead, brown, cankered areas, often extending right around it. In cases where the stems have been more vigorous or the attack less severe, the girdling may have only been sufficient to partially prevent the flow of sap downwards. In such cases a cluster of small tubers may be found close to the base of the stem, and very commonly small green tubers are formed above ground in the angles between leaf and stem. These aerial tubers are very characteristic of the disease, but may be produced from other causes leading to partial girdling; e.g., the breaking of the stem by wind. Another stage of the fungus in the form of a greyish mould on the stems also occurs in late summer and produces spores, but the chief means by which the disease is spread is by the planting of tubers bearing sclerotia. In addition to potatoes, a large number of cultivated plants are liable to attack from this stem-rot, with consequent dwarfing or wilting of the plant. "Damping-off" of seedlings in the seed-bed is also often caused by this fungus.

Control.—When once present in the soil it is impossible to "starve out" the fungus, since there are so many plants, including weeds, on which it can live. It

Fig. 11. *Rhizoctonia* on potato-tubers.

is important, however, to avoid as far as possible introducing it into the soil. Seed-treatment with corrosive sublimate is effective, but formaldehyde is unreliable and often worthless. However, the sclerotia are very resistant to the penetration of liquids, and the fungus-tissue in the interior of the larger ones may remain unin..red by any treatment that is safe for the tubers. For this reason it is best to discard altogether, for seed purposes, tubers bearing large sclerotia.

Dry-rot and Wilt (*Fusarium oxysporum*).

This disease affects the underground parts of the plants in the field. As a consequence the foliage takes on an unhealthy colour and the leaves curl in from the margins. The shoots die prematurely and the yield is diminished. In the field, however, unless severe, the disease is likely to pass unnoticed. Affected tubers may shrivel up with dry-rot in storage. They also seem to offer better facilities for the invasion of the bacteria which produce wet-rot. Wet-rot in the field during the past season seemed particularly abundant in hills affected with the *Fusarium*. Many tubers may, however, go through the winter without apparent change, and these, if used for seed, serve to introduce the disease into the soil. When once introduced, the fungus may persist in the soil for several years. Affected tubers may be detected by cutting them across close to the stem end, when a ring of brownish spots will be seen marking the position of the vascular bundles.

Control.—Avoid using for seed tubers which show the discoloration referred to. Do not grow potatoes again for several years on land which has borne a diseased crop. Seed-treatment is useless against this disease.

Sun-scald and Tip-burn.

These are physiological troubles which may result from prolonged hot sunny weather, but more rapidly when such weather follows a dull cloudy period. The tip and margins of the leaf present a black scorched appearance which in bad cases may extend almost to the midrib. Where the crop is sprayed with Bordeaux mixture this trouble is diminished, probably through some of the light being screened off.

Fig. 12. Potato infected with *Fusarium* wilt. Note the discoloured vascular ring when a slice is cut off at the stem end. (*After Circ. 4, Div. of Botany, Dom. Dept. of Agr.*)

QUINCE.

FIRE-BLIGHT.

Quinces are liable to suffer severely from this disease. (*See* under "Apple.")

RASPBERRY.

ANTHRACNOSE (*Glœosporium venetum*).

This attacks also the blackberry and loganberry, the symptoms being much the same in each case. The chief injury is done to the canes on which brown sunken spots appear. These are usually elongated in the direction of the stem and surrounded by a purplish area. In bad cases they become confluent, thus giving rise to areas of considerable size in which the tissues are destroyed, and seriously interfering with the functions of the stem. Spores are produced in the centre of these spots. The disease also causes a spotting of the leaves, which, however, is of trifling importance with us. In the Pacific Coast States a serious rotting of the fruit is also reported, but this has not been observed here.

Control.—As soon as the fruit has been picked the old canes should be cut out and burned. Badly affected young canes should be removed at the same time. Spraying is reported to have given good results in some cases, but has not been very extensively adopted. Resin Bordeaux mixture, 4-4-40 formula, should be used owing to the nature of the surface of the cane, to which the ordinary mixture does not adhere satisfactorily. Spray first before the buds burst, then when the young canes are about 6 inches high, and again just before blossoming-time.

CANE-BLIGHT (*Coniothyrium fuckelii*).

This is quite a serious disease on the Lower Mainland. It usually first attracts attention by the wilting of the cane at the time the fruit is maturing. In some

cases the fruit may wither up before the cane as a whole dies. Fruit-spurs and leaves are commonly sent in for examination by those ignorant of the nature of the disease, in the belief that the cause of the trouble will be found there. This is not the case, however, the drying-up of the berries, leaves, and other portions of the cane at one point being due to the failure of the sap-supply, which in turn is due to the destruction of the sap-conducting tissues at some point lower down the stem. Such canes, if examined carefully below the wilted portion, will show the presence of dead brittle areas, lighter in colour than the healthy parts, and which may extend all around the cane. Fruiting-bodies are formed in the outer layers of the bark of the affected areas and are visible as minute dark-brown or black points. The surface of the cane in their vicinity is often covered with a smoky-brown powder of escaped spores. The fungus probably gains entrance in most cases through wounds It is probable also that it can exist for an indefinite time on fragments of dead canes in or on the ground.

Control.—This is a difficult disease to control. In starting a plantation every care should be taken to secure healthy stock. Affected canes should be removed as completely and as soon as possible and burned. Refuse, such as broken canes, etc., should be collected and burned. Raspberries should not be planted again for a considerable time on land that has borne a badly diseased plantation. Spraying has so far proved of doubtful value.

CROWN-GALL.

Raspberries often suffer severely from this. Such plants can be detected by the yellow, unhealthy foliage and stunted appearance of the plant. They should be dug out carefully and burned and only some non-susceptible variety of plant put in their place. Any plant found infected when the plantation is being set out should not be planted, but destroyed.

ROSE.

POWDERY MILDEW (*Sphærotheca pannosa*).

This is well known to rose-growers, being the commonest fungus enemy of the rose. There is a great difference between different varieties in regard to susceptibility, the Crimson Rambler being one of the worst. The fungus, like other powdery mildews, forms a white or grey mouldy growth over the leaves, young shoots, and flower-buds. On this mycelium numerous spores are produced through the season, and by means of these the fungus is enabled to spread rapidly. Affected leaves wrinkle and curl up and the young shoots are distorted. Later in the season little black fruiting-bodies may be formed in the mycelium, but commonly these are not noticeable. Sudden changes of temperature render the plants more liable to severe attacks of the disease.

Control.—In mild cases dusting with flowers of sulphur when the dew is on or after rain is of benefit. Spraying with potassium sulphide (liver of sulphur), ½ oz. to a gallon of water, is more effective, but the sulphur in this form acts upon the lead in white-lead paint to produce a black-lead sulphide. Hence, if used to spray rose-bushes against a verandah or other structure painted white, the results may be very disconcerting. In such cases the flowers of sulphur should be tried. The potassium sulphide solution must be made up afresh each time, as it decomposes on standing. When lime-sulphur is on hand it may be used instead at a dilution of about 1 to 30. It may be necessary to discard the most susceptible varieties.

RUST (*Phragmidium subcorticium*).

This is a very common disease. In the early part of the season it appears as orange-red pustules on the stems, leaf-stalks, leaf-veins, and calyx. The orange-red colour is due to the formation at these points of enormous numbers of summer spores. Later in the season these are replaced by black masses of resting spores. No satisfactory control measures are known, one difficulty being the abundance of the disease on wild roses. However, although disfiguring, it rarely causes serious injury.

LEAF-BLOTCH (*Actinonema rosæ*).

This causes irregular black spots on the upper surface of the leaves, somewhat resembling those of apple-scab. Badly affected leaves turn yellow and fall prematurely.

Control.—The spraying recommended for mildew will help to keep off this disease also, but Bordeaux mixture is more effective.

STRAWBERRY.

LEAF-SPOT (*Mycosphærella fragariæ*).

This disease, also commonly, but unfortunately, known as "rust," is the chief fungus trouble of this plant. It appears as spots on the leaves, at first bright reddish or purplish in colour. Later, these consist of an ashy-grey centre surrounded by a red or purple area. In severe attacks much of the leaf-surface may be destroyed and a large part of the leaf shrivel up. Summer spores are produced on the older central portions of the spots. From the hybernating mycelium in the old leaves another type of spore is produced which probably forms the source of the spring infection.

Control.—Pick off and burn any affected leaves at the time of setting out a new plantation. Mow closely and burn the leaves after the fruit is picked, if the disease has been at all bad. Spraying is of assistance in keeping the disease in check, but does not seem to be necessary, as a rule, where other precautions are observed and plantations are not allowed to remain too long.

TOMATO.

LEAF-SPOT (*Septoria lycopersici*).

Appears as small pale spots on the leaves. When very numerous they cause the leaf to curl and shrivel up. It is rarely serious enough, however, in this Province to call for treatment.

BLOSSOM END OR POINT ROT.

This is one of the most serious diseases of the tomato. It affects the fruit only. The disease first appears as one or more water-soaked areas near the *style* or tip of the fruit, usually when the fruit is half-grown or more. The tissues in these water-soaked areas collapse and they then form flattened or sunken areas of a dark-green to black colour and of a hard, leathery texture. Various bacteria and fungi may gain entrance at these injured spots and produce a rot which rapidly destroys the whole fruit. The black velvety covering commonly seen on such spots is the spore stage of one of these fungi.

Control.—The exact cause of the disease is still obscure, and hence recommendations of a general nature are all that can be made. It seems pretty well established, however, that the first cause is not a parasite of any kind, although organisms may do much to hasten the final rotting. Plants that are much forced, especially in the earlier stages, are more susceptible. A check in the water-supply is liable to cause a serious development of the disease in such cases. On the other hand, excessive watering also predisposes the plant to the disease, especially on the heavier classes of soils. Heavy manuring with barnyard manure tends to increase the disease. Usually it is worst on light, sandy soils.

WESTERN BLIGHT.

This has been reported from various points in the Okanagan. Affected plants have a dwarfed, "bunchy" appearance and fail to mature fruit. The leaves turn yellow, or yellow mottled with purple; the veins turn purple and the leaves curl. The root system is stunted and the smaller root-fibres show evidence of injury.

Control.—There is evidence that the disease is due to a soil-fungus which gains entrance through injuries to the root made in transplanting. With the ordinary

procedure, therefore, there is little that can be done, except to take every care against injuring the roots in transplanting. It has been suggested that the seed-bed be done away with, and the seed "planted four to a hill and in hills 3 to 4 feet apart in the field." When 5 or 6 inches high the plants are thinned out one to a hill. Whether this would be of practical value under our conditions is doubtful, although on an experimental scale it has been found to much reduce the loss.

WHEAT.

Stinking Smut or Bunt (*Tilletia foetens* and *T. tritici*).

The life-history of this parasite is the same as that of the fungus causing smut of oats, except in certain minute details. The effect on the crop, however, is much more serious. In oat-smut, as a rule, the black spores and the damaged chaff are blown away before harvest, so that, although the yield is reduced, the quality is not impaired. In the case of bunt the fungus does not attack the chaff, but only the interior of the kernel. This becomes filled with a dark-brown, greasy mass of spores which has a very powerful and objectionable odour of putrid fish. Since these affected kernels remain in the ear and are harvested and threshed with the sound grain, they communicate their dark colour and disagreeable odour to the sample of flour made from such grain. Affected kernels are shorter and broader than normal ones and cause the chaff to stand apart more. They are also lighter and can therefore be picked out by their broader appearance and more erect habit. As in the case of oat-smut, and for a similar reason, if a plant is attacked at all, usually every ear and each kernel in the ear will be affected.

Control.—The method given under oat-smut is satisfactory, but there is one additional precaution necessary. The affected kernels or "smut-balls," as they are commonly called, may go through harvesting, threshing, and seed-disinfection without being broken. The disinfecting solution cannot penetrate these unbroken kernels sufficiently to kill the contained spores. However, it is quite likely that some of these balls may be broken subsequently in the operations connected with seeding, thus contaminating the seed again with live spores and undoing the effects of the treatment. It is therefore necessary to remove unbroken "smut-balls" before treatment, if the sample is found to contain them. Most of them can be taken out with the fanning-mill, but if any are left the grain should be put loose into a barrel or other vessel of water and stirred vigorously. The smut-balls being lighter will rise to the surface and can be skimmed off and burned. They should not be left around or the spores may find their way again into the seed. If this method has to be resorted to, it is better to follow it by immersion in the formalin rather than by sprinkling.

Bluestone Method.—This is satisfactory for wheat, though not for oats. A ½-per-cent. solution is commonly employed—i.e., 1 lb. in 20 gallons—and the seed soaked twelve hours. It is then taken out, drained for a few moments, and dipped in lime-water (1 lb. lime to 8 or 9 gallons of water). This is done to counteract the injurious effect which the prolonged action of bluestone has on the germination of the seed. The seed is then dried and sown. Drills and other implements must also be disinfected.

Loose Smut (*Ustilago tritici*).

This resembles in appearance the loose smut of oats, since it completely destroys the kernels and chaff. By harvest-time nothing is left of the ear except the bare stalk. The life-history of the fungus, however, is quite different. Spores are blown by the wind into the open flowers of near-by healthy ears. Here they germinate, each spore producing a fungus-thread which enters the developing kernel and gives rise to a rudimentary mycelium. This remains dormant in the germ of the seed until such an infected seed is sown. When the germ becomes active and begins to grow out into the seedling, the mycelium becomes active, too, and behaves from this

time on much like the oat-smut fungus. It will be seen, therefore, that at sowing-time the fungus is *inside* the kernel as mycelium and not adhering to the *outside* as a spore. Seed-disinfection with chemicals is therefore useless, since anything which would penetrate into the seed to reach and kill the mycelium would also kill the grain. A method has been found of treating the seed with hot water for a few minutes, by which the fungus can be killed without material injury to the grain. The operation is a rather delicate one, however, since the temperature must be kept within very narrow limits, otherwise the treatment will be ineffective, or, on the other hand, the germinating power of the grain will be destroyed. The method, therefore, is only applicable to small quantities of seed, such as may be used to seed a plot to furnish the general seed-supply for next season. As this disease is not serious in the Province, details for treating the seed are not given here, but will be furnished on application to the Plant Pathologist.

INJURIOUS INSECTS.

It has been estimated that the annual loss to farm crops in Canada from the ravages of insect pests is somewhere in the neighbourhood of $50,000,000. It is therefore obvious that every farmer or fruit-grower should be acquainted with the most improved methods of combating his insect foes. In order to intelligently apply such remedies, however, it is necessary for him to know something about the insects themselves, their structure and life-history.

A knowledge of the structure of insects is essential, for upon this depends, to a very large extent, the methods adopted for their control. For this purpose insects are divided into two main classes: (1) Sucking-insects, and (2) biting-insects.

To the sucking-insects belong the aphides, leaf-hoppers, mealy bugs, etc., whose mouth-parts are modified into a long sucking-tube, with which they pierce through the skin of the food-plant and suck up the juices within. Stomach-poisons would be of no avail against insects of this class, so some material must be applied that will kill them by contact. All insects breathe through tiny openings in the sides of their bodies. It is the object of contact sprays to close up these openings by covering them with a film of the spray, or else destroy them by the caustic action of the spray upon their bodies.

Biting-insects include all those forms that chew and swallow their food. The various leaf-eating caterpillars belong to this class. As these insects actually take portions of their food-plant into their systems, they can be controlled by the use of stomach-poisons, like arsenate of lead. Soft-bodied biting-insects may sometimes be destroyed by the use of contact sprays.

A knowledge of the life-history of any insect pest is necessary in order to tell at what period in its life it can be most readily destroyed. Insects, during the course of their development, pass through the following stages:—

(1.) The first is the egg stage, during which the insect is usually invulnerable to attack with sprays.

(2.) The egg hatches into what is known as the larva. If the adult insect is a fly, the larva is called a maggot; if a moth or butterfly, a caterpillar; if a beetle, a grub; other larvæ have no special names. The larval stage is the growing and feeding period of an insect's life, when the most injury is done, and is usually the time when they can be most conveniently destroyed.

(3.) The third stage is the pupal or resting period, during which the insect remains quiescent and takes no food. In this stage the larval organs change to those of the perfect or adult insect.

(4.) The fourth stage is the adult or perfect form. The adult insect is usually winged, and during this period there is no further growth, only sufficient food being taken to maintain the vital activities of the insect.

Some insects have no pupal stage, and the second period in their life is called a nymph instead of a larva. Examples of this class of insects are grasshoppers, scale-insects, aphides, and others. Examples of those having all four stages are the tent-

caterpillars, fall web-worm, pear-tree slug, etc. The most important points to observe in the control of insect pests are: (1) Prevention as far as possible; (2) strict attention to details in the preparation of the remedy to be employed; and (3) thoroughness and timeliness of application.

Preventive measures are usually the cheapest and the most easily accomplished. They are, first, clean culture; that is to say, not allowing rubbish to accumulate on the land. When the crops have been gathered, remove, or destroy if necessary, all waste material from the land; do not wait until the spring to do cleaning-up; there is too much other necessary work to attend to at that time. In the final cleaning-up in the fall gather all waste material into convenient heaps on the land and allow them to remain there until frosty weather sets in; these will prove attractive traps for a large number of insect pests which are looking for comfortable winter quarters to hibernate in. They should then be burned where they lie. This will destroy many pests. A further method of prevention which should not be neglected is that of spraying before insect pests have commenced to do injury. This is also economical and will save a great deal of trouble and expense during the growing season. There are, however, important and essential points necessary in accomplishing this successfully. These are a knowledge of what is to be sprayed for, what spray to use, and when to apply it; also of whether the number of such particular pests will be sufficiently great or destructive to warrant the expenditure of the time and material necessary. It is quite obvious that the grower, to be able to decide this for himself, must have a fair knowledge of the pests he is about to contend with. Unfortunately the general conditions in British Columbia have reached a point where it is in most cases necessary to apply an annual dormant spray in the orchards. If the fruit-grower cannot decide for himself what his orchard actually requires, his local Inspector can give him much assistance in the matter, providing the grower will take him sufficiently into his confidence. Many growers seem to have a tendency to hide what may appear to them a slight infestation only of an insect pest, either in fear of dire penalties or else through ignorance of the nature of the insect in question, which may not appear to be harmful. In either case there is the great danger of ultimate severe losses, not only to the individual grower, but to the whole community should it prove to be a serious pest.

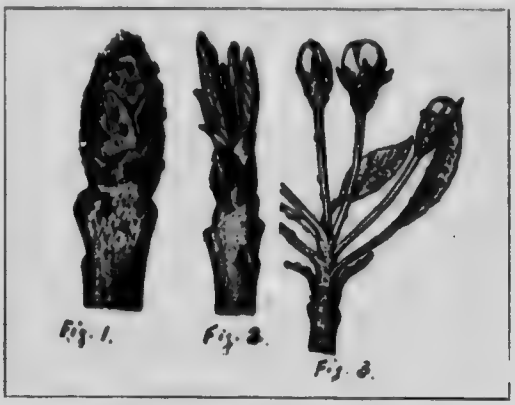

Fig. 13. Apple-aphis. (1.) Stage of development of the buds when first control spray can be effectively applied. (2.) In this stage of development spraying not effective. (3.) Stage of development when a second application is most effective. (*Figs from Circular 23, Geneva Experiment Sta., N.Y.*)

In the present day of severe competition growers must endeavour to become acquainted to some extent with the insect pests they have to contend with and the proper time and methods of control. In this matter lies, to a great extent, the secret of success in farming. It is a great matter to the grower whether he has a 90-per-cent. perfect crop or only 25 to 50 per cent. Culls and injured crops have little market value. Economy in production is an ideal basis to work on, but where to economize is a problem to be solved by each individual producer, and he should not make a start by reducing the quality of his marketable crops.

Growers are particularly requested to send in specimens of insects with which they are not acquainted, and these will be identified for them. This would materi-

ally assist in the accumulation of data of the insects present in British Columbia and also of their distribution. This is undoubtedly the best way for the growers to become acquainted with the pests which are causing, or are likely to cause, injury to their crops; this is most important to the growers. Do not think that because an insect is small or not very numerous that it is of no economic importance. It might, at some future time through increase, cause extensive losses, so do not wait until the damage is done before looking for a remedy. If the growers would undertake to follow out these suggestions they would not only materially help themselves, but greatly assist in the accumulation of important data in the shortest time.

In sending specimens the following points should be observed:—

In all cases where possible living specimens of the insects should be sent enclosed in a strong wooden or tin box to prevent their being crushed in the mails. Larvæ should be supplied with a liberal quantity of their food-plant, and in all cases should be carefully packed.

The name and address of the sender should be written on the outside of the package, and a letter should in all cases accompany the insects sent, giving as full details as possible of the following: The extent of the injury caused; the name of the plant or tree on which the insects were found; if a remedy has been tried to control the insects; if so, the name of the remedy, when applied, and the apparent result.

Address all communications to the Entomologist, Department of Agriculture, Vernon, B.C.

Thanks are due to R. C. Treherne, B.S.A., the Field Officer for British Columbia of the Dominion Entomological Branch, who has kindly read over the manuscript of the following pages and made various suggestions and corrections. He has also furnished the summary of the remedial measures recommended for the control of the strawberry-root weevil, which are the result of his extended observation and experiments.

THE APPLE-APHIDES (GREEN APHIS, ROSY APHIS).

The green aphis of the apple is an annual source of worry to many of our fruit-growers. This pest passes the winter in the egg stage on the smaller branches and twigs of apple-trees. The small, black, shiny eggs are easily observed on the trees during the winter and early spring, in favourable seasons the eggs being so numerous as to make the twigs appear black. The eggs generally commence to hatch a little before the buds show green and continue to hatch over a period of two or three weeks. The spring forms of the aphides are wingless and are called stem mothers. They are the only ones that hatch from true sexual eggs, all the following generations being born alive. At times during the course of the season winged forms appear which are known as the migrants. These winged forms leave the parent colonies and migrate to other trees, where they commence producing young aphides alive; these young aphides form the summer colonies. Migratory forms continue to appear until the true sexual males and females appear in the fall; the females then deposit eggs until frost stops them.

THE ROSY APHIS.

This pest, if allowed to increase, may be considered more serious than the green aphis. They are found principally round the young fruit-clusters, to which they cause severe injury, resulting in the fruit remaining small and becoming gnarled and misshapen. As yet these aphides are not very numerous in the Province.

Control.—It is important that the control of these pests be undertaken when the stem mothers are emerging from the eggs and previous to the time when the leaves commence to curl. Spray should be applied thoroughly with not less than 180 lb. pressure, just when the buds are opening. If spraying has been neglected until the trees are in leaf, it is important that the spray be particularly directed

against the under-side of the leaves. If left until the leaves are curled, spraying cannot be accomplished effectively.

The following formulæ are recommended:—

(a.) Lime-sulphur, 1 part to 9 parts of water, plus 1 part nicotine sulphate 40 per cent. to each 1,000 parts of diluted lime-sulphur spray. This formula must be applied just before the buds open.

If the trees are not sprayed before they are in leaf, or, if so, where another application is deemed necessary, one of the following formulæ may be used: —

(1.) Nicotine sulphate 40 per cent., 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of the dilute solution.

(2.) Lime-sulphur (30° Baume), 1 part to 30 parts of water, plus 1 part nicotine sulphate to each 1,000 parts of the dilute lime-sulphur spray.

Important.—Do not use soap with lime-sulphur solution. Thoroughness of application and attention to detail are essential.

Fig 14. Result of a severe infestation of woolly aphis on an apple-tree. Note the excrescences on the twigs. (*Photo, Mr. Tom Wilson.*)

THE WOOLLY APHIS OF THE APPLE (*Schizoneura lanigera*).

This pest has perceptibly increased in several districts of British Columbia during the last three years. It attacks the twigs and branches of the trees, and may also be found on the roots, the root form being the most serious. A severely attacked tree assumes a sickly appearance and the leaves become dull and yellowish. Later, if the tree is not killed outright, it is so weakened that it becomes especially susceptible to the attack of borers and other insect pests, as well as fungus-diseases.

The insects, with the exception of the last generation, both on the roots and above ground, are all females, and are of a reddish-brown colour, but covered with a white waxy secretion, especially the aerial forms. In October a number of winged individuals appear among the colonies. These are also all females, but are the parents of a true sexual generation of minute wingless aphides, the females of which each lay but a single winter egg. This part of the life-history has not been as yet sufficiently investigated. In some instances where it has been followed up the eggs have been found to be laid on the elm or some other host-plant to which the winged females have migrated. A certain proportion, however, of the eggs appear to be laid on the apple in the fall.

Control.—The aerial forms present no especial difficulty, a thorough application of 40-per-cent. nicotine sulphate, 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of the dilute spray, being sufficient to control it. Apply the spray with at least 200 lb. pressure soon after the pests are noticed on the trees. The result will be in due proportion to thoroughness of application. The root form is more troublesome to control. It will be necessary to uncover the roots of the infested trees to a depth of 12 to 18 inches, according to the size of the tree and extent of infestation. The same mixture as recommended for the aerial form will be effective if poured around the roots and allowed to soak down to the aphides.

Fig. 15. Apple-tree leaf-hopper. Greatly enlarged. (*After Forbes.*)

THE APPLE-TREE LEAF-HOPPER (*Empoasca sp.*).

Quite a difficult pest to control. There are about four broods each year which overlap each other, so that all stages of the insect may be found during the summer. The winter is passed in both the adult and the egg stages. It is a very general feeder, attacking a great variety of trees and plants. The female deposits her eggs just under the bark of the young immature wood, giving the bark a pimply appearance which is very noticeable when the foliage is off the trees. There are five nymphal stages before the adult stage is reached.

Control.—As soon as the young nymphs are noticed in the spring (about the middle of May they are most abundant) apply 40-per-cent. nicotine sulphate, 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of the dilute spray. If this spray is well applied and at the right time, it will materially reduce injury from this insect. Adult hoppers on bush-fruits or nursery stock may be materially reduced by driving screens coated with tanglefoot along the rows and close to the young trees or bushes.

THE CODLING-MOTH (*Carpocapsa pomonella*).

This is one of the most serious pests that the fruit-growers of the Province may have to contend with. The egg is a flat, somewhat oval-shaped object about the size of a pin-head; it is laid and glued to an apple or a leaf; at the time of hatching

the larva is about 1/30 to 1/16 inch in length, of a semi-transparent whitish or yellowish colour, with large, shiny black head and dark cervical and anal shields. The body shows regularly arranged spots with short hairs. When full-grown the larvæ are about ¾ inch in length. The majority are of a pinkish or flesh colour, which is much lighter or absent on the under-side. The spots in which the minute hairs are situated are but little darker than the body-wall, but can be easily distinguished with a hand-lens. The adult insect or moth is quite variable in size, but the wings never expand over ¾ inch. The tip of the front wings bear a large dark-brown spot on which there are two irregular broken rows of scales, which have a coppery metallic colour, and with some reflections of light they appear golden. The codling-moth passes the winter as a hibernating larva in a silken cocoon, under loose rubbish, loose bark, cracks and crevices of apple-trees, in houses where wormy fruit has been stored, or in boxes which have been used for handling wormy fruit; in fact, in any convenient place near to where a larva may have left a wormy fruit. Early in the spring the larvæ that have survived the winter change to pupæ, the adults emerging about the time the young fruit has formed. In cases of severe infestation, where proper control methods have not been adopted, the entire apple-crop may become unmarketable through the attack of this pest.

Control.—At the present time any outbreak of this pest is dealt with by officials of the Department of Agriculture with a view to its eradication. If a wormy apple is found in your orchard, notify your nearest Inspector and send specimens to the office of the Plant Pathologist and Entomologist, Vernon, B.C.

THE LESSER APPLE-WORM (*Enarmonia prunivora*).

The larva of this moth is sometimes mistaken for the larva of the codling-moth, as it attacks the fruit in a similar manner. In several States of the Union this moth is considered a close second to the codling-moth as an injurious pest. It was first reported as being present in British Columbia in 1895 by the late Dr. James Fletcher. The moth has been bred from various host-plants and is probably a native of the North American Continent.

Control.—Owing to the close resemblance of its work to that of the larva of the codling-moth and the difficulty of growers not acquainted with the two pests to distinguish between them, it is advised that any infestation of this nature be reported to the nearest Inspector and treated according to his instructions.

THE BUD-MOTH (*Tmetocera ocellana*).

This insect is becoming a serious pest in British Columbia. The insect passes the winter as a hibernating larva about three parts grown, emerging in the spring about the time the buds begin to expand. The time of emergence may vary by as much as two weeks, depending on the earliness of the season. If the buds are not open when they leave their winter quarters they will gnaw into them; if open they crawl inside. They attack both leaf and fruit-buds and sometimes bore down inside the twigs for a few inches. The adult stage is reached early in the summer, the young larvæ of the new brood emerging towards the end of June. These attack the fruit as well as the foliage, and if in considerable numbers will materially injure the crop.

Control.—A spray of arsenate of lead 2 lb. to 40 gallons of water thoroughly applied when the buds begin to swell will materially reduce this pest. The arsenate of lead might be advantageously used in combination with the regular application of lime-sulphur in the spring; i.e., add 2 lb. of arsenate of lead to each 40 gallons of dilute lime-sulphur.

THE OYSTER-SHELL SCALE (*Lepidosaphes ulmi*).

Little attention has been given to this scale by many fruit-growers, consequently it has rapidly increased in all districts. There is only one brood each year, the young hatching in late May or early June. The winter is passed in the egg stage.

Fig. 16. Oyster-shell scale. (a) Female scale from below showing eggs; (b) same from above, greatly enlarged; (c) female scales on twig, about natural size; (d) male scale enlarged; (e) male scales, about natural size. (*From Year-book, 1894, U.S. Dept. Agr.*)

Control.—This scale is very resistant to sprays, except in the young stage, immediately after hatching, when it may be easily controlled. The young hatch from the last week in May to the first or second week of June, the variation being due to locality and climatic conditions. The fruit-grower should therefore carefully watch for the appearance of the young scales, which will appear as tiny yellow specks on the bark, and if closely watched will be seen to move. As soon as these are observed an application of nicotine sulphate 40 per cent., 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of solution, should be immediately applied, as only a few days will elapse before the young scales attach themselves to the bark or fruit and commence to cover themselves with their protecting scale. Apply spray with a power-sprayer, using not less than 200 lb. pressure.

THE EUROPEAN FRUIT-SCALE (*Aspidiotus ostreæformis*).

This insect, which somewhat resembles the San Jose scale in appearance, has become a common pest within the last few years. The fully formed scale of the adult female often reaches a diameter of $^{2}/_{25}$ inch. It is circular, and, if it has been rubbed or self-ruptured, shows the small orange-coloured larval exuvia. In the San Jose scale this exuvia is reddish-yellow, though in some cases dark-coloured, the female scale being a little smaller than the European fruit-scale; i.e., $^{1}/_{25}$ to $^{2}/_{25}$ inch. It is, however, so difficult for the average fruit-grower to distinguish between the two that it is desirable to send in suspected specimens to the office of the Plant Pathologist and Entomologist, Vernon, B.C., for identification. This pest attacks plums, apples, pears, apricots, nectarines, peaches, and has also been found on the cultivated currant. It is also quite common on some of our native wild trees, and frequently found associated with the oyster-shell scale (*Lepidosaphes ulmi*). Severe injuries and even the death of severely infested trees are caused by this insect.

Control.—The application of lime-sulphur, 1 part to 9 parts of water, in the early spring, when the trees are still dormant, is desirable, but a summer treatment should also be given as for the oyster-shell scale, *which see.*

SAN JOSE SCALE (*Aspidiotus perniciosus*).

This is a pest with which the British Columbia fruit-grower has not, as yet, to contend, and it is to be hoped he may retain his immunity for a long time to come. If this is to be the case, however, it is necessary that the grower take sufficient interest in the matter to report any suspicious case. The pest is common and destructive in the Pacific States, and there is always a danger of its being introduced. As mentioned in the preceding article on European fruit-scale, there is a close resemblance between the two species, and expert knowledge is often necessary for their discrimination. Anything suspicious should therefore be sent to either the Vernon or Vancouver office for determination. Outbreaks of San Jose scale are dealt with by the Government inspection staff with a view to complete eradication, and hence it is not necessary here to enlarge on control measures.

The Round-headed Apple-tree Borer (*Saperda candida*).

This insect takes two years to complete its life-cycle. The adult beetles commence to emerge from the middle of May to about the end of July. The female eats out a small slit in the bark in which it deposits an egg, which is often pushed under the bark and then covered with a gummy substance. The eggs hatch in two or three weeks. The young larvæ tunnel just under the bark on the sap-wood, usually working down towards the base of the tree. At the beginning of the second season the larvæ are about ⅝ inch long. They continue in the sap-wood during the second season, and it is at this time the most serious damage is done, for where several occur in a tree they may girdle it.

The next season they penetrate into the heart-wood, and several of them will fairly riddle a small tree-trunk with their cylindrical burrows. The full-grown larvæ continue these burrows out into the bark, often cutting clear across a tree. When the fully grown larva has completed its tunnel nearly through the b[illegible] it pupates, and emerges as an adult beetle about three weeks later.

Control.—(*See* "Flat-headed Apple-tree Borer.")

The Flat-headed Apple-tree Borer (*Chrysobothris femorata*).

[illegible]væ of this beetle live just beneath the bark, where they hollow out broad [illegible]ch [illegible]which extend slightly into the sap-wood. Infestation may be detected by [illegible]e discoloration of the bark. Where abundant they will often completely girdle young trees, thus causing their death. They are frequently found under the loosening bark of dying limbs of large apple-trees.

The adult beetles emerge from about the middle of May until about midsummer. The eggs are deposited in crevices in the bark. The larva becomes full-grown in one year, remaining in the pupal stage about three weeks bef[illegible] emerging as an adult beetle through an elliptical exit-hole in the bark.

Control.—Mechanical barriers to prevent the females from depositing their eggs on the tree-trunks are sometimes used. These barriers are usually composed of fine-mesh wire netting or building-paper wrapped round the trunks. The base of such a barrier must be placed an inch or two below the surface of the ground and extended up to the lower branches of the tree. When wire netting is used as a barrier it must be kept from contact with the trunk by packing the top with cotton batting or other suitable material. This is to prevent the beetles from depositing their eggs on the bark through the meshes of the wire. These protectors should be placed in position early in May and kept in place until late summer.

Other deterrents which have been recommended are heavy washes of soap to which a small quantity of carbolic acid is added, and then painted in a thick coat on the trunk and lower limbs. Heavy limewashes have also been advised.

The Fruit-tree Leaf-roller (*Archips argyrospila*).

This insect is responsible for a large amount of low-grade and deformed fruit every year, the greatest injury being done to the fruit during the early stages of its growth. The larvæ eat holes into the fruit which, though healing over during growth, leave a corky scar, and in the more serious cases cause a malformed growth. One larva may attack a considerable number of fruit, so that not many need be present to cause extensive injury.

Control.—This is a difficult insect to control during its active state owing to its habits. The most effective spray is a 10-per-cent. solution of crude-oil emulsion applied before the eggs hatch; i.e., about the time the buds are beginning to open.

The Tent-caterpillars (*Malacosoma spp.*).

These caterpillars are usually kept well in check by parasites or other natural agencies. In favourable seasons, however, their unsightly tents are very conspicuous on the wild cherry and are frequently found in considerable numbers in our orchards, where, if allowed to develop unchecked, they soon defoliate whole limbs or even

entire trees. The tent is at first a delicate silken web spun between the fork of two branches, but soon becomes an unsightly mass, about 2 feet long, filled with cast skins and excrement. On warm, sunny days the caterpillars feed outside the tent.

Control.—The control of these caterpillars is not difficult, and there is no reason for allowing them to multiply unchecked in our orchards. The fruit-grower should be on the look-out for the egg-masses when he is pruning his trees, and destroy them. The eggs are laid in masses of about 200 encircling the smaller twigs of the trees. When the tents are evident in the wild brush in the vicinity of the orchard they should be cut out and burned, or they may be burned out with a torch. Tents on the fruit-trees can be conveniently collected with a wire brush fastened on the end of a pole (a stove flue-brush would serve the purpose). Start early in the morning or on a dull day when the caterpillars are inside the tents; insert the brush through a tent and revolve the brush so as to wind the tent containing the caterpillars on the brush; remove them from the brush and place them in a receptacle containing water with a little coal-oil on top. Arsenical sprays are also effective if applied to the foliage near the tents. Collecting is, however, the most economical method.

ANTIQUE OR RUSTY TUSSOCK-MOTH (*Notolophus antiqua*).

This caterpillar is principally a leaf-eater, but will occasionally eat large holes into the fruit. Though not a serious pest, it has become fairly abundant in recent years. Many fruit-growers no doubt have noticed the old female cocoons, covered with masses of eggs, attached to the smaller twigs and leaves on their trees during winter or early spring.

Control.—Examine trees during winter or early spring when pruning, and destroy all cocoons found with egg-masses on them. Do not remove cocoons which have no egg-masses on them, as these are probably parasitized cocoons from which beneficial insects would eventually emerge.

If the caterpillars are present in injurious numbers during the spring, the trees may be sprayed with arsenate of lead, 2 lb. to 40 gallons of water. This spray should be applied before the young caterpillars attain any appreciable size, for as they grow they become more resistant to the poison. They can also be jarred from small trees and prevented from returning by placing sticky bands round the trees. Trees that are regularly sprayed with arsenicals are never greatly troubled with them.

If caterpillars are well-grown and it is found desirable to spray for them, 4 lb. of arsenate of lead to each 40 gallons of water will be necessary to be effective.

THE YELLOW-NECKED APPLE-TREE CATERPILLAR (*Datana ministra*).

This is a leaf-eater, quite common in our apple-orchards. During August one may frequently see the ends of apple-limbs defoliated for a foot or two. On a close examination the group of caterpillars causing the injury can be easily recognized. The caterpillar, when full-grown, is about 2 inches long, with a jet-black head, and the first segment behind the head is a bright orange-yellow. Down the middle of the back runs a black stripe, and on either side of the body are three black stripes alternating with four yellow ones. The body is thinly coated with long soft white hairs. The caterpillars are gregarious and feed in colonies; if disturbed they will at once assume a position characteristic of this genus, throwing the head and tail into the air and remaining motionless in this position for some time.

Control.—Owing to the gregarious habits of these caterpillars they can be easily removed from a limb and destroyed. Cutting off the part of the limb on which they are noticed will remove the whole brood. Arsenate of lead, 3 lb. to 40 gallons of water, applied as soon as they are observed will destroy them, but gathering the colonies by hand is the most economical method of control.

THE RED-HUMPED APPLE-TREE CATERPILLAR (*Schizura concinna*).

This is another leaf-eating caterpillar much the same in habits and manner of injury as the yellow-necked apple-tree caterpillar. There is only one brood each

year, and they are known to feed on apple, plum, cherry, rose, thorn, willow, blackberry, and other related plants. The common name given this insect very well describes the peculiar shape and colour of the caterpillar.

Control.—(*See* "Yellow-necked Apple-tree Caterpillar.")

THE FALL WEB-WORM (*Hyphantria cunea*).

The common fall web-worm is so named because of the web which it spins over its food-plant during August and September. The moths emerge from over-wintering pupæ late in June. The eggs are laid by the female moths during the month of July, and are deposited on the leaves of its food-plants in clusters of 400 to 500. These usually hatch in about ten days. The young caterpillars immediately commence to spin their webs over the foliage on which they are feeding. Within this web the colony from one egg-mass feeds, enlarging the web as it becomes necessary. The webs are usually started at the tips of the twigs, and first become noticeable early in August. When the foliage in one web is entirely consumed the colony will leave it and spin a fresh web upon a new branch. When the larvæ are full-fed they seek a place in which to pupate, usually under loose bark on the trees or rubbish at its base; fence corners are also acceptable.

Control.—Cut off the webs containing the caterpillars and destroy them.

THE TARNISHED PLANT-BUG (*Lygus pratensis*).

A pest which is very troublesome in many countries and has proved particularly injurious in orchards and truck-gardens in this Province. The adults hibernate over winter and emerge in the first warm days of spring. They do extensive injury by attacking the buds of fruit-trees, vines, canes, and plants. Later the young terminal shoots are also attacked and injured. Their principal breeding-places are in meadows, range land, and among weeds in and about the orchards and fields.

Control.—Although extensive experiments have been conducted over many years, the control of this pest is yet an unsolved problem. Clean culture has been recommended by a number of [illegible] but has not proved effective. The insects are very active creatures, and there is always a sufficient breeding area near by to produce an abundance of bugs.

The removal of all rubbish and waste material from the orchards and fields in the fall will, to a great extent, remove hibernating-quarters for the insects on cultivated lands. This may check early invasion and permit the trees and plants to make some development before injury is done. Keeping them in vigorous growth will overcome much of the injury from this pest.

THE PEAR-THRIPS (*Euthrips pyri*).

This is a very serious insect pest and was first recorded in this Province in the spring of 1915. It is believed to be confined to one locality in the Province as yet, but it is thought advisable to warn the fruit-grower against this pest on account of its serious nature.

The adult, which is the most destructive stage of the species, is a dark-brownish, four-winged insect about $^1/_{20}$ inch in length. The wings are long and narrow and are delicately fringed with long hairs; when at rest they lie horizontally along the back of the insect and are very inconspicuous. The feeding of this insect causes much damage to fruit-trees. The insects seek, preferably, the rudimentary flower and leaf parts in the partially opened buds, but when the buds are more fully developed they feed more or less openly on the stamens, pistils, petals, tender leaves, and apparently on the secretions from the nectaries in the centre of the blossoms.

If the thrips are numerous the injured buds become sticky with a brownish liquid and cease to develop, while the blossom-clusters have a stunted, shrivelled, and brownish appearance as if blasted. The effects of the attack of the thrips on fruit yields depends on the number of blossom-buds destroyed. The period of activity of

this pest is from about the end of April to the end of May, about eleven months of the year being spent in the ground. Prunes and cherries are also subject to severe injuries.

Important.—The control of this pest at present, in the infected area, is being directed by the Government. Where the presence of the pear-thrips is suspected, growers are particularly requested to send in material for identification. Enclose blossom-clusters and leaves with the suspected thrips on them in a tight tin or wooden box, and mail to the office of the Plant Pathologist and Entomologist, Court-house, Vernon, B.C.

THE CHERRY AND PEAR SLUG (*Eriocampoides limacina*).

This insect is a common pest of pear, cherry, plum, and other fruit-trees. Although not difficult to control, it is frequently permitted to cause considerable injury. The larvæ are of a yellowish-white colour when they emerge from the eggs, but rapidly acquire a coat of dark-green slime (an exudate of the body), which gives them the appearance of slugs, in which state they are well known to fruit-growers. The adult is a four-winged insect which belongs to a group known as sawflies. There are two broods annually. Although the larvæ, or slugs, may be found during the whole of the season, from the end of May to the end of September or early October, they are most abundant during the latter part of May and again during late August and September.

Fig. 17. Cherry and pear slug. (*a*) Adult female; (*b*) larva with slime removed; (*c*) same in normal state; (*d*) leaves with larvæ, showing injury. (*a*), (*b*), (*c*) enlarged; (*d*) slightly reduced. (*After Marlatt.*)

Control.—Forty-per-cent. nicotine sulphate, 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of solution. If no aphides are present on the trees the soap may be omitted, in which case increase the strength of nicotine solution to 1 part to 800 parts of water. Arsenate of lead, 1 lb. to 40 gallons of water, may also be used, but this does not kill the larvæ so quickly, and if weather conditions are favourable may burn the foliage of the cherry to some extent. White hellebore, 1 lb. to 40 gallons of water, is also very effective and is cheaper than the nicotine sulphate. To get good results from this spray the hellebore must be fresh and unadulterated. An application of one of the above formulæ should be given as soon as the larvæ appear numerous. In the home garden, where perhaps only one or two trees are affected, dusting them with air-slaked lime, or *fresh* pyrethrum, 1 part mixed with 8 to 10 parts of cheap flour or air-slaked lime, is advised.

THE PEACH-ROOT BORER (*Sanninoidea opalescens, S. exitiosa*).

This is a troublesome pest and is making considerable headway in the peach districts of the Okanagan Valley. Considerable loss is being caused through its injuries. Peaches are most susceptible to attack, but prunes, cherries, apricots, apples, and plums are also attacked. The adults emerge during the early part of July, soon after which the females commence depositing their eggs. The egg stage lasts about two weeks, and as soon as the young larvæ hatch they bore into the bark just below the surface of the ground, and feed on the sap-wood of the trees. Complete girdling of the trees results and death often ensues.

Control.—In order to prevent injury from this insect, it is necessary to prevent the larvæ from reaching the underground portion of the tree. This is accomplished by encircling the trunk at the ground with a flexible soil-covering mat which must be impenetrable to the borers and impenetrably sealed to the tree. Mr. W. M. Scott, late State Entomologist of Georgia, and Mr. E. B. Blakeslee, of Washington, D.C., have both adopted the same method of control as the result of continuous independent experiments.

The following is a summary of Mr. W. M. Scott's method as described by him at a meeting of the American Association of Economic Entomologists: Tar-felt mats 16 inches in diameter are used. Cut a hole in the centre of each mat to conform to the diameter of the trees, and slit from the hole to the outer edge. The soil is first mounded somewhat around the tree and the protector placed over the mound. The slit edges are lapped and glued together with a viscous material, and the protector is sealed to the tree with the same material, completely filling all openings, so that it is impossible for the borers to reach the soil without crawling away from the tree beyond the outer edge of the protector. The viscous material for effecting an absolute sealing to the tree is an essential feature of the protector. Mr. W. M. Scott has applied for a patent on the sealing medium he used; Mr. Blakeslee has found the use of tanglefoot successful.

The Peach-twig Borer (*Anarsia lineatella*).

This insect is of considerable importance in the peach-growing sections of British Columbia. The insects hibernate in the form of immature larvæ in cells just under the bark, the top of the cells extruding from the bark and covered with frass. These cells are built in the crotches of the trees. In the first warm days of spring, when the buds are opening, the larvæ leave their cells and commence feeding on the buds, and, later, frequently bore down the young terminal twigs a distance of 2 or 3 inches, killing them, and thereby injuring the trees. Later in the season larvæ enter the fruit, making it unmarketable. If left unchecked extensive losses will result. Peach-orchards close in, which have been cut up into town lots, have been observed to be a great source of infestation. By actual count one seven-year-old peach-tree on a neglected unoccupied lot was found to have 96 per cent. of the fruit infested. Prunes are also attacked. There are several broods each year. More information is required both on the life-history of this insect and its control.

Control.—The remedies at present recommended are the dormant spray of lime-sulphur, 1 part to 10 parts of water, applied just before the buds open. Care must be taken to thoroughly saturate the crotches of the trees. During the last week of July an application of arsenate of lead, 3 lb. to 50 gallons of water, might be applied, particularly on the fruit; this will prevent a large percentage of the larvæ from entering the fruit.

The Cottony Maple-scale (*Pulvinaria innumerabilis*).

This scale has been unusually numerous both in the Lower Okanagan country and at the Coast the last two years. It is usually kept well in check by natural enemies. Should a severe infestation occur, endangering the health of shade-trees, control methods should be adopted to protect the trees and also prevent migration to orchard trees. This insect is single-brooded. The young scales hatch from June to early July, according to locality, and settle on the twigs of maple and other shade-trees, and occasionally on fruit-trees.

Control.—Forty-per-cent. nicotine sulphate, 1 part to 1,000 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of solution. Apply in the early spring with a power-sprayer. In orchards they should be well controlled with the usual spring application for aphides.

The Raspberry-root Borer (*Bembecia marginata*).

This insect is beginning to appear in injurious numbers in British Columbia. The adult insect is a clear-winged moth bearing some resemblance to a wasp. The

adult insects emerge from the end of July to late September. They are sluggish and move about slowly. The females deposit their eggs on the under-side of the leaves of the blackberry and raspberry, each female laying from 100 to 150 eggs, which hatch in late September or early October. As soon as the young larvæ are hatched they crawl down and enter the base of the canes, feeding but a short time. In this young state they remain dormant all winter. They commence to feed and work their way downwards through the pith early in the spring, and feeding is continued until the following autumn, when, as well-grown larvæ, they again pass the winter in a dormant state. Feeding commences again in the following spring, the larvæ commencing to work up the canes until at the approach of the pupation period, on reaching the end of their tunnels, they eat through the wood until only a very thin covering of bark remains. Pupation then takes place, which may be any time from the beginning of July to late August. When emergence is about to take place the pupa forces itself partly through the remaining covering of bark and the adults appear shortly afterwards.

Control.—Examine canes in the fall or spring when thinning and pruning; remove all infested plants and burn them.

RASPBERRY-CANE MAGGOT (*Phorbia rubivora*).

This is the larva of a small fly somewhat resembling a house-fly, but smaller. It attacks the young canes of raspberry, blackberry, and allied plants. The egg is laid in spring or early summer in the axil of a leaf (i.e., in the angle between the leaf and the stem) near the tip of a shoot. From this a small whitish maggot emerges which bores its way into the pith of the cane. It then eats its way down the cane for some distance, bores its way outwards until just under the bark, and from this point eats out a burrow right around the cane, effectually girdling it. As a consequence, the part of the cane above this point wilts and dies. The larva continues to eat its way down the pith and eventually pupates in the lower part of its burrow. The fly emerges the following spring.

Control.—Affected canes, as soon as the wilting is noticed, should be cut off well below the point where they have been girdled and burned. The line of girdling can usually be detected as a bluish ring visible externally. This treatment carefully carried out will reduce the infestation the following season.

THE CURRANT AND GOOSEBERRY FRUIT-FLY (*Epochra canadensis*).

This is the most serious pest of the currant and gooseberry in this Province. It attacks the fruit itself, making it quite worthless. The eggs are deposited under the skin of the fruit, usually one to a fruit. From this a small maggot hatches which bores into the interior of the fruit. The first indication that the fruit is attacked appears as a discoloured spot on the injured side, and the underlying tissue appears opaque. Growth of the berry on this side ceases, and consequently the berry becomes deformed. It ripens prematurely and then falls off. The larva generally remains in the fruit until it falls, then it pupates in an earthern cell at a depth of 1 or 1½ inches below the surface of the soil. The adult emerges in the following May. It is a two-winged fly about the size of a house-fly, of a yellow or orange colour, with dusky bandings on the wings.

Control.—From the fact that the egg is laid beneath the skin of the fruit, and the insect during its injurious stage is buried in the tissue of the fruit, control is difficult. Poultry allowed to run amongst the bushes will pick up the fallen berries with their contained larvæ, thus lessening the possible infestation for the succeeding year. Spading over the ground to a depth of 4 or 5 inches close up to and for some little distance away from the bush, in late summer or fall, will kill some of the pupæ and expose others to the action of the weather and their natural enemies, insectivorous birds. Poultry running over the ground would also be useful at this stage. Mulching the ground in spring heavily with straw has been suggested to prevent the emergence of the fly. Owing to the habits of pest, spraying to prevent

attack is useless. In the case of certain very similar pests, however, beneficial results have been obtained by spraying with a sweetened poison to kill the adult flies and thus prevent egg-laying. The following formula might be tried: Cheap brown sugar or molasses, 3 lb.; lead arsenate, 4 oz.; water, 5 gallons. This must be applied as a fine spray to the foliage at intervals of five to six days, making the first application early in May. (Honey should not be used as the sweetening agent, as it is likely to attract, and thus cause the poisoning of, bees.)

The Imported Currant-borer (*Ægeria tipuliformis*).

This is a European insect which has spread to all parts of the United States and has recently become a prominent pest in this Province. The adult is a clear-winged moth and is very similar in appearance to the raspberry-root borer, as is also the larva. The moths appear by the first of June and deposit their eggs in the axils of the leaves next the canes. The young caterpillars bore into the pith of the canes.

Control.—The only method of control is to keep the old wood removed and to cut out and burn all affected canes in the fall or early spring.

The Strawberry-root Weevil (*Otiorhynchus ovatus*).

This is the most serious pest the strawberry-grower has to contend with. It is destructive both in the larval and adult stages, the adult injuring principally the foliage and the larva destroying the roots of the plants. The weevil is single-brooded, and the adult beetles may be found alive and active at any time of the year. The insect has numerous host-plants and passes the winter in both the larval and adult stages.

Control.—R. C. Treherne, B.S.A., Dominion Field Officer for British Columbia, who has recently made a thorough study of the control of this pest, gives the following recommendations:—

Deep ploughing, deep cultivation, application of lime and stable manure, all previous to the year of planting, followed in June, after the crop is removed, by the destruction of the old leaves and stocks, hoeing, hand-weeding, and the application of a complete fertilizer, will be found the most expedient methods suitable to the culture of strawberries in a weevil-infested district. Fall planting can only be adopted in especially heavily infested localities.

Ploughing up the plantation at the termination of its usefulness is best done immediately the spring crop is removed, especially on small farms of 5 to 10 acres. On large farms, owing to the rapid succession of other crops, ploughing is better delayed until September or October.

Whatever the size of the farm or prevailing conditions, it is advisable to plough at the end of June, or very early July, or let the ground remain untouched until fall.

The effect of crop-rotation on large farms is marked, and represents one of the most efficient methods of controlling the depredations of the weevil. On small farms the effect is not so marked. The use of chickens in conjunction with rotation is strongly urged, allowing them free range over the plantation following the summer ploughing.

Cutworms.

The variegated cutworm (*Peridroma saucia*) is one of the most destructive that the growers of the Province have to contend with. It is a most cosmopolitan feeder, almost any kind of vegetation being acceptable. Field crops, truck crops, and fruit-trees suffer to a considerable extent every year. In a late spring, when little vegetation is available, they will attack young fruit-trees, eating not only the buds, but also stripping the bark off the tender branches. The life-history is not well known, but undoubtedly two broods occur in British Columbia, the first brood being most prominent during April and early May, the second during the month of August. The adult is a night-flying moth. The winter is passed in the larval, pupal, and adult stages in the ground.

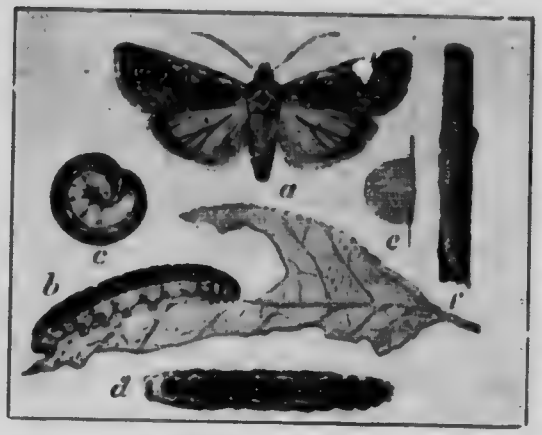

Fig. 18. The variegated cutworm. (a) Adult moth; (b), (c), (d) full-grown larvæ; (e), (f) eggs. All about natural size except (e), which is greatly enlarged. (*After Howard, U.S. Dept. Agr.*)

Control. — The best-known remedy is a poison bran-mash, prepared as follows: Coarse bran, 50 lb.; Paris green or white arsenic, 2 lb.; syrup or brown sugar, 2 quarts; warm water, sufficient to make a coarse, crumbly mash. The dry ingredients should first be thoroughly mixed together and the water then added. Do not get the material too sloppy; have it so it will fall apart readily after pressing together in the hand; 15 lb. of the mixture is sufficient for each acre if the material is broadcasted over the ground. It is best to apply the mixture in the early spring after the ground has been ploughed and harrowed and before it has been seeded or planted. In the orchard it is better if the ground is ploughed in the fall, so that the poison can be applied in the spring before any vegetation starts into growth.

WIREWORMS.

These are the larvæ of a family of beetles (Elateridæ) commonly known as "click-beetles." The larvæ are slender and worm-like, with a tough, leathery skin of a yellowish or reddish-brown colour. The body is divided into well-defined segments, and each of the three just behind the head has a pair of short stout legs. The head is furnished with a pair of strong jaws. The larval stage lasts from three to five years, so that the amount of damage which these grubs can do is very great.

Control.—This is difficult owing to the fact that the grub is well protected by its tough coat and feeds below the surface of the soil. Badly infested land should be ploughed in late summer or early fall and kept well harrowed. This will kill some of the larvæ and pupæ and expose others to their natural enemies, such as insectivorous birds. Poultry allowed to run on the land at this time would be of assistance. In gardens, or where the infestation is especially bad in limited areas in a field, trapping may be useful. For this purpose the poisoned bran-mash given for cutworms (*which see*) may be used, but owing to the habits of the wireworms it is better to place it under boards, flat stones, etc., rather than throw it on the surface of the ground. Infestation is generally much worse in grass land, or in the crop following the breaking-up of this. Hence a short rotation with as little seeding-down to grass as possible is advisable.

THE CABBAGE-ROOT MAGGOT (*Phorbia brassicæ*).

The cabbage-maggot is the immature form of a fly which resembles, but is somewhat smaller than, the common house-fly and has proportionally larger wings. The adult female is capable of laying about fifty eggs during the course of her existence; these are deposited on the ground near the plants. When the eggs hatch the young larvæ work their way through the soil to the roots, first eating the young rootlets and later attacking the main root. The results are so serious that the plants often die. They are particularly destructive to newly-set-out cabbage-plants, the early varieties suffering most. There are several broods each year.

Control.—This is a difficult pest to control. Quite a number of remedies have been experimented with, some of which have proved more or less effective, but in the main too expensive to be of much commercial value. Preventive measures should be adopted. Procure some tarred felt paper, from which cut small disks (as per illustration) about 4 inches in diameter. Similar disks may be purchased ready made from the Plant Protector Co., 25 South Water Street, Rochester, N.Y., at $2 per 1,000 in lots of less than 5,000; larger amounts at proportionally less rates. The cutting-tool can be made by any blacksmith. Place a disk around each plant as soon as they are set out in the permanent plantation. This will prove a deterrent to the fly and is accepted now as the most successful method for small and large areas. In those sections where seed-beds are raised in the open ground the young seedlings may be screened by means of a cheese-cloth frame.

Fig. 10. Cabbage-root maggot. Adult female, greatly enlarged. (*From Bulletin No. 382, Geneva, N.Y.*)

Disks for the Protection of Young Cabbage-plants.—The disks are cut in the shape of a hexagon (Fig. 1) from paper known as "single-ply tarred felt." The tool used in cutting these disks can be made by any good blacksmith by reference to Fig. 2. The blade or cutting-edge is formed from a band of steel bent into the form of a half-hexagon, with an additional strip reaching from one end nearly to the centre as shown in Fig. 2. The part making the star-shaped cut is formed from a separate piece of steel bolted to the handle (a piece of 2- x 4-inch), and so attached as to make a close joint with the blade. The edge of the blade is bevelled from the outside all round, so that by removing the part making the star-shaped cut the edge may be sharpened. In order to cut the disks, the tarred paper should be placed on the end of a section of a log as figured (Fig. 3) for convenience and rapid cutting. The lower edge of the paper should be notched as indicated in Fig. 4, using only one angle of the tool; then begin the cutting at the left side, placing the cutting-edge as shown by the dotted line, Fig. 4.

THE CABBAGE-APHIS (*Aphis brassicæ*).

These insects are found in every cabbage-patch and may be found on all the cultivated and wild cruciferæ. Cabbages and turnips are, however, the most seriously injured by them.

Control.—Nicotine sulphate, 1 part to 1,200 parts of water, plus 5 lb. of whale-oil soap to each 100 gallons of spray. Apply when the aphides are present on the plants.

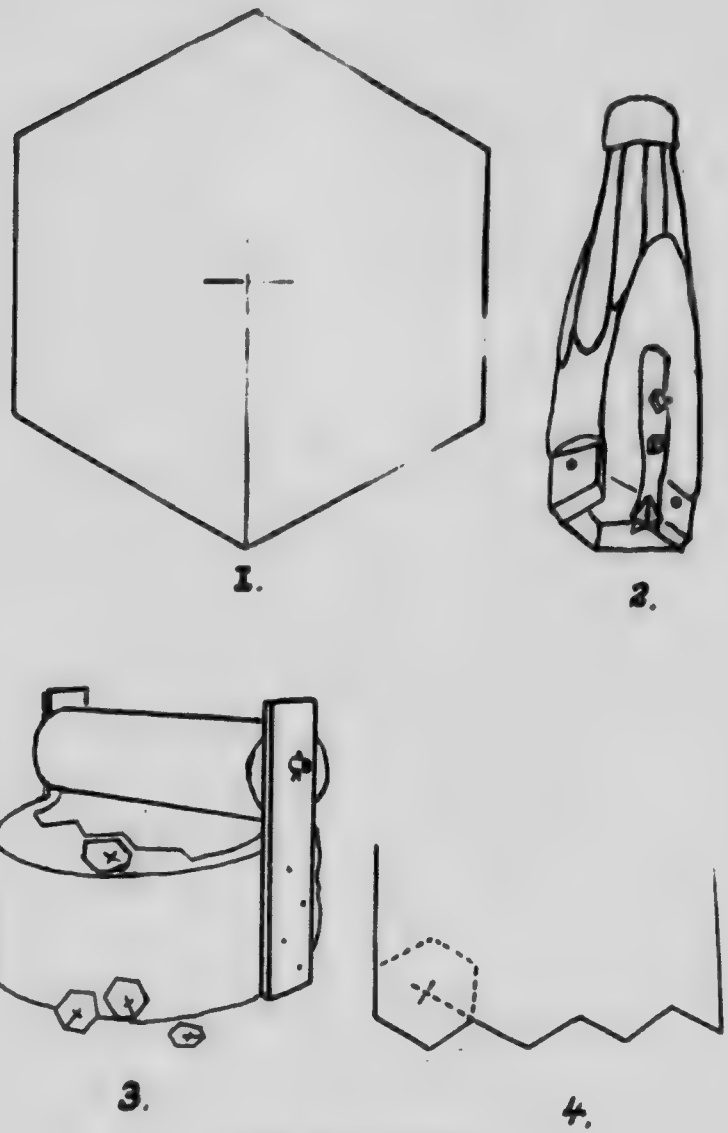

Fig. 20. Maggot instruments.

The Onion-maggot (*Phorbia cepetum*).

The presence of the onion-maggot is first shown by the plants changing to a yellowish colour and finally wilting. On examination one or more maggots may be found feeding in the interior of a plant. This maggot is the larva of a two-winged fly bearing a close resemblance to the house-fly. This insect passes the winter in the pupal stage in the ground. There are several broods each season.

Control.—It is recommended to remove all infested plants found while thinning and burn immediately. Change of land is also recommended.

Fig. 21. The onion-maggot. (*a*) Adult; (*b*) larva; (*c*) puparium; (*d*) anal spiracles, enlarged. (*From Ent. Rept., 1909, N.J.*)

The Small White Cabbage-butterfly (*Pontia rapæ*).

This insect was imported from Europe and first became conspicuous on the North American Continent in 1865. It is now one of our most common pests and is responsible for extensive losses to vegetable-growers every year. This insect passes the winter in the chrysalis stage on rubbish in the field, on fence-rails, under the eaves or buildings, or any other convenient place. There are several broods each year which overlap each other, so that all stages of the insect may be found throughout the summer months. These butterflies are familiar objects and are readily recognized by the growers. The caterpillar is the destructive stage and is generally referred to as the green cabbage-worm.

Control.—When the caterpillars are present, dust the plants with a mixture of pyrethrum powder, 1 part to 10 to 15 parts of cheap flour. See that the pyrethrum powder is fresh when purchasing and store in air-tight canisters.

The Diamond-back Moth (*Plutella maculipennis*).

This insect is an importation from Europe. It attacks the under-side of the leaves of many plants. It has been observed during the past two years in unusually large numbers in certain localities in British Columbia. The adult is a very small moth, which may be readily noticed when flying in large numbers in a cabbage or turnip field. They remain in close proximity to the plants they attack, and do not apparently indulge in extensive flight. There are several broods each year.

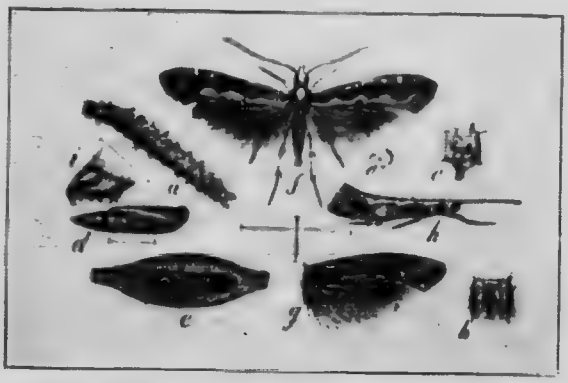

Fig. 22. The diamond-back moth. (*a*) Larva; (*b*) segment of same greatly enlarged; (*d*) pupa; (*e*) pupa in cocoon; (*f*) adult moth; (*g*) wings of dark variety; (*h*) moth with wings folded. (*After Riley, U.S. Dept. Agr.*)

Control.—(*See* "Cabbage-butterfly.")

WESTERN POTATO FLEA-BEETLE (*Epitrix subcrinata*).

This insect is very troublesome in potato-fields throughout the Province. It also attacks tomato-plants. The adult, which is the destructive form, is a small black-brown beetle, which from its characteristic jumping powers has been very appropriately named "flea-beetle." There are two broods in a season, the adults of the second generation appearing in the fall. These hybernate and attack the crops in the spring. The greatest amount of damage, however, is done by the summer brood, the adults of which appear about the middle of July.

Small holes are eaten in the leaf around which the leaf-tissue dies. Very often, also, the early-blight fungus obtains entrance through these injuries.

Control.—Spraying with Bordeaux mixture alone, as is done against late blight, acts as a deterrent. Paris green or arsenate of lead may be added to this to make it more effective, or these may be used alone; 2 to 3 lb. of arsenate of lead or ½ lb. of Paris green should be used to 40 gallons of water. In the latter case ½ lb. of freshly slaked lime should be added. Paris green may also be used dry. It should be mixed with land-plaster at the rate of 1 lb. of Paris green to 20 lb. of land-plaster, and dusted over the plants in the early morning when the dew is on. In the case of tomato-plants protection may be secured by dipping the whole plant, except the roots, before planting, in a mixture of 1 lb. arsenate of lead in 10 gallons of water.

GRASSHOPPERS OR LOCUSTS.

These pests are often responsible for extensive losses in grain and fodder crops. Truck crops are also attacked and destroyed, and even young orchards may be seriously damaged towards the end of summer when the ranges commence to dry up. Such trees may be completely stripped of foliage and of much of their bark by the pests, especially if they adjoin waste or range land. Eggs are deposited in large numbers where the soil is dry and comparatively free from vegetation, as in old pastures and waste or range land. Egg-laying takes place in late summer or autumn, the young locusts hatching out about May of the following year.

Control.—The Kansas Experiment Station formula is recommended: Bran, 20 lb.; Paris green or white arsenic, 1 lb.; molasses, 2 quarts; oranges or lemons, 3 fruits; water, 3½ gallons. In preparing the bran-mash the bran and the poison are thoroughly mixed while dry. The juices of the fruit are squeezed into the water, and to this is added the pulp and peal after chopping into fine pieces. The molasses should then be added to the water, and when dissolved the mixture should be poured on to the dry bran and poison, stirring the whole constantly so as to dampen the bran thoroughly.

The damp mash should be sown broadcast in the infested areas early in the morning; that is, about the time the locusts are beginning to move about. It should be scattered in such a manner as to cover 5 acres with the amount of bait made by using the quantities of ingredients given in the above formula. Since very little of the bran is eaten after it becomes dry, scattering it broadcast in the morning, and very thinly, places it where the largest number will find it in the shortest time. As the poison bait does not act quickly, it will be from two to four days before the locusts will be found dead, and the bodies will be most numerous in sheltered places.

THE PEAR-LEAF BLISTER-MITE (*Eriophyes pyri*).

This mite winters over under the bud-scales of the young wood. As the leaves expand in the spring the adult mites spread over the under-side of the leaves, the females burrowing under the epidermis and depositing their eggs in the burrows. The young larvæ feeding in the tissue of the leaves cause malformed growths in the

form of blisters, so prevalent in our pear-orchards. The blistering of the leaves is more apparent on the upper surface of the leaves, which turn at first reddish and, later, brown. In severe infestations the vigour of the tree is greatly impaired.

This year (1915) the mites were more in evidence than usual in the Okanagan Valley and attacked the young fruit to a considerable extent. This mite attacks the apple, quince, hawthorn, and other trees, but serious injury has so far only been observed on the pear.

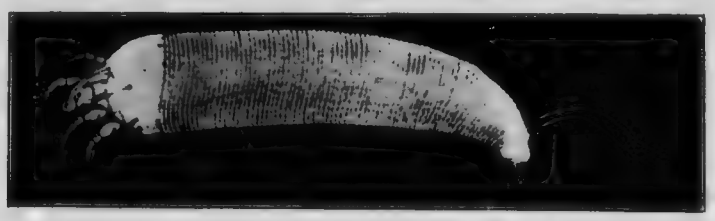

Fig. 23. Pear-leaf blister-mite, highly magnified. (*After Parrot.*)

Control.—Lime-sulphur, 1 part to 9 parts of water, applied just before the buds open, has generally proven satisfactory in the control of this pest. It must, however, be applied at the right time. If applied after the mites have deposited their eggs under the epidermis of the leaves the spray cannot be effective. Experiments conducted in the State of New York indicate that a distillate or kerosene emulsion spray gives the best results.

THE RED SPIDER (*Tetranychus bimaculatus*).

The red spider is present every year in large numbers and is a source of worry to many growers. It is a very indiscriminate feeder, attacking a large variety of plants. The plants most susceptible to serious infestation are greenhouse plants, hops, bush-fruits, prunes, and plums. The adults hibernate over winter in the ground. Early in the spring those that have survived the winter ascend the trees or plants in their immediate vicinity. They spin fine silken webs on the under-side of the leaves on which the females deposit their eggs, and feed on the under-side of the leaves under their webs. They multiply very rapidly, and in favourable seasons are responsible for a great deal of injury. The fruit on severely attacked trees remains small and does not mature properly.

Control.—In greenhouses the frequent application of a coarse stream of water applied to the plants with considerable force has so far proven the most satisfactory means of control. For hops, bush-fruits, fruit and shade trees, use lime-sulphur, 1 part to 80 gallons of water, plus flour paste 4 gallons to each 80 gallons of dilute lime-sulphur spray. This spray must be applied through a fairly coarse nozzle with considerable force; a power outfit is necessary and a pressure of at least 200 lb. employed. Apply as soon as the red spiders are noticed on the plants or trees, directing the spray principally against the under-side of the leaves and seeing that they are thoroughly coated with the spray mixture. A second application should be made seven to ten days after the first application, so as to catch the spiders that were still in the egg stage at the time of the first application. The spray is not effective on the eggs. A band of tanglefoot 3 or 4 inches wide applied round the trunks of the trees in the early spring will prevent migration to the trees. This would, however, require frequent renewal.

To prepare the Flour Paste.—Mix a cheap grade of wheat-flour with cold water, making a thin paste without lumps. Dilute until there is 1 lb. of flour to each gallon of water; cook until a paste is formed, stirring constantly to prevent caking or burning. Add sufficient water to make up for the loss from evaporation. Use 4 gallons of this paste to each 80 gallons of diluted lime-sulphur spray.

GARDEN SLUGS.

These are frequently injurious to vegetation, particularly under moist conditions.

Control.—Trapping by placing out shingles or boards is quite effective. Examine the traps every morning and crush the slugs collected under them. Liming the soil is also useful. If slugs have collected on the plants, dust them with a mixture of lime 5 parts and fresh hellebore 1 part. Providing the hellebore is fresh, this is very effective and does not injure the plants.

SPRAYS AND SPRAYING.

The spraying of fruit-trees for the control of fungous and insect pests is of comparatively recent origin. Bordeaux mixture, which is one of the oldest fungicide sprays on the market, was introduced into the United States in 1887. It is evident, therefore, that our present knowledge of the above topic is subject to change, and that we can hope to see in the near future better sprays, spray outfits, and systems of spraying than we have at present. The information given here is the consensus of the opinion of growers and instructors as to what is considered the best in these lines at the present time.

Some fruit-growers believe that in order to make their orchards productive it is only necessary to spray. Nothing could be more fallacious, as the causes of unproductiveness are many. When such causes are due to insect and fungous pests, spraying is, in most cases, a specific. When the cause of unproductiveness is poor soil, lack of tillage, poor varieties, etc., spraying can only have a secondary effect in correcting the barrenness of the plantation. In orchards which have been neglected in districts where orchard pests do serious damage, the owner should not expect to obtain perfect results the first year. Spraying being a preventive, in a large number of cases it is advisable to spray every year, especially in such districts as are mentioned above.

Economical and successful spraying does not depend altogether on methods of application, but depends to a marked extent on the condition of the orchard. Varieties differ in their blossoming and fruiting periods, etc., and as a consequence require sprays applied at varying periods, especially where some pests, such as apple-scab, brown-rot, and codling-moth, are to be controlled. In an orchard containing a large variety list per acre, successful spraying is made difficult and expensive.

Trees with high heads are hard to spray, and more spray is wasted in covering them than with a low-headed tree. Spraying accomplished from the ground is generally more thoroughly done than from an elevated position. These facts point strongly to the value of low-headed trees for economy and good results in spraying.

Spraying, especially in the case of some of our fungous diseases, has to be most thoroughly done, and all parts of the tree must be covered before satisfactory results can be obtained. A tree which contains superfluous wood will not produce the highest quality of fruits and is difficult to spray. This condition is also conducive to the spread of fungous diseases. Fruit-trees, especially in the non-irrigated districts, should be kept well thinned out in order to produce high-quality fruits and make the spraying operations economical and successful. The relation of successful spraying to conditions in the orchard as mentioned above, i.e., low-heading of trees and pruning, are most important. They are conditions that are desired in a commercial orchard, so that the fruit-grower who keeps his orchard in good condition is in a position to obtain the best results in spraying.

A careful perusal of the circular on orchard pests will no doubt impress the reader with the value of knowing the pests he has to control, the use of correct mixtures, and the value of spraying at the right time. When the time comes for spraying, have everything ready, and do not delay the operation for something which might appear at a casual glance to be more important. A difference of a few days in application sometimes gives a difference of 50 per cent. or more in results.

The value of thoroughness in application cannot be overestimated. In controlling pests it is sometimes necessary to prevent the germination of "seeds" or spores, which are so small that they can be seen only by the use of a powerful microscope. From this, the value of thorough work is appreciated.

Sprays can be considered from the standpoint of effectiveness, cost, manufacture, effect on spray-machines, etc. In comparing the values of the sprays that are on

the market at the present time, a large number can be discarded, which do not come up to the best ones when considered from the above factors. New sprays are being frequently advertised, and the growers are warned against their extensive use until they have been tried and proved safe, economical, and successful by the experiment stations. A great deal of damage has been done in the past through the use of new sprays before they had been thoroughly tested by the experiment stations.

INSECTICIDES.

(FOR THE CONTROL OF BITING-INSECTS.)

Arsenate of Lead (Paste Form).—Two to four pounds to 40 gallons of water. Keep the lead covered with water so it will not dry out. Stir well the required amount of poison with a small amount of water before adding to the spray barrel or tank, so as to ensure a good mixture.

Arsenate of Lead (Powdered Form).—Seldom used in this country and not recommended in this bulletin in any of the formulæ given. This form is twice as strong as the paste form, and should any one desire to use it only one-half the quantity of paste should be used. One to two pounds to 40 gallons of water.

White Hellebore.—Loses its poisoning properties after being exposed to the air. Sometimes for this reason it can be used on small fruits and on plants when the fruit is just about ready to be picked with much more safety than the mineral poisons. This also shows the necessity of using fresh material from which the air has been excluded. Can be used either in the powdered form or diluted with water. Use 1 oz. to 2 gallons of water.

Paris Green.—Much less satisfactory than arsenate of lead. It washes off the plants easier, does not spread so well, and sometimes burns foliage. Used occasionally against insects that require a large amount of poison to kill them. It should not be used with lime and sulphur, but may be used with Bordeaux, which usually carries an excess of lime.

Paris green is usually used at the rate of about ½ lb. to 40 gallons of water. It is always well to mix about 1 lb. of freshly slaked lime in the water and let stand a while before using. This will overcome the danger of burning to a large extent. It can also be used in the powdered form and dusted on the plants to be treated. This is best accomplished in the morning before the dew has dried off the plants.

Carbolic Acid Emulsion.—Dissolve 1 lb. of hard soap, shaved fine, in 1 gallon of boiling water; add 1 pint of crude carbolic acid and churn violently. For use, dilute to 25 gallons. Sometimes used around the base of cabbage-plants to destroy the cabbage-maggot.

Poisoned Bran-mash.—For use in the control of cutworms. Mix well 1 lb. of Paris green with 50 lb. of bran, moisten to the consistency of fresh sawdust, and sweeten with a little sugar or molasses.

CONTACT INSECTICIDES.

(FOR THE CONTROL OF SUCKING-INSECTS.)

(1.) *Forty-per-cent. Nicotine Sulphate (Black Leaf 40).*—This is a liquid preparation made from tobacco stems and waste material in the large tobacco plants, and is put up in various size tins. The best-known form is the proprietary "Black Leaf 40." For the control of green aphis ¾ pint of the nicotine solution and 3 to 5 lb. of soap in 100 gallons of water. In mixing soap, shave it fine and dissolve in hot water so that it will mix readily. For woolly aphis and rosy apple-aphis use 1 pint nicotine sulphate and 4 or 5 lb. soap to 100 gallons water.

(2.) *Whale-oil Soap and Quassia-chips—*

Whale-oil soap	1 lb.
Quassia-chips	1 lb.
Water	12½ gals.

Boil the quassia-chips in 1 gallon of water for an hour. Dissolve the soap in hot water. Strain and mix both solutions together and dilute with water to make 12½ gallons of mixture.

FUNGICIDAL SPRAYS.

(1.) *Lime-sulphur.*—This spray, both for summer and winter spraying, is becoming very popular. It is an efficient fungicide, and also is useful in the control of many insect pests. It can be manufactured by the grower without infringement on any patent, but it is found at present prices of manufacture to be more economical to buy the commercial mixture. Most brands on the market have been giving good satisfaction, among which are some manufactured in our own Province. It is a good plan to have on hand a hydrometer (specific gravity and Beaume scale attached) to test the commercial mixture before using. The reading as given by the hydrometer is not always a sure indication of the strength of the commercial mixture, as something might be added which would raise the hydrometer test without increasing the fungicidal strength of the spray. With most commercial mixtures it can be used to advantage.

Dilutions.—The following is a table showing dilutions of different strengths of commercial lime-sulphur. This shows the dilutions which are giving the best results.

TABLE FOR DILUTING CONCENTRATED LIME-SULPHUR SOLUTIONS.

Reading on Degrees Beaume.	Hydrometer Specific Gravity.	Amount of Dilution. Number of gallons of water to one gallon of lime-sulphur solution. For dormant spray.
36	1.310	1 gallon lime-sulphur.....9.3 gallons water.
35	1.299	1 gallon lime-sulphur.....9.0 gallons water.
34	1.288	1 gallon lime-sulphur.....8.6 gallons water.
33	1.288	1 gallon lime-sulphur.....8.2 gallons water
32	1.267	1 gallon lime-sulphur.....7.9 gallons water.
31	1.256	1 gallon lime-sulphur.....7.5 gallons water.
30	1.246	1 gallon lime-sulphur.....7.2 gallons water.
29	1.236	1 gallon lime-sulphur.....6.9 gallons water.
28	1.226	1 gallon lime-sulphur.....6.5 gallons water.
27	1.216	1 gallon lime-sulphur.....6.2 gallons water.
26	1.206	1 gallon lime-sulphur.....5.9 gallons water.
6	1.041	1 gallon lime-sulphur.....0.4 gallon water.
5	1.034	1 gallon lime-sulphur.....0.1 gallon water.

Some growers think it better to add some lime. This is not necessary, as it does not strengthen the spray, but in some cases it is supposed to have the opposite effect. When it is added, it is advisable to use the spray within a few hours after mixing or it will deteriorate.

For sprays following the dormant spray the following dilutions are recommended: Lime-sulphur, spring strength, for apples and pears; dilute the commercial preparation, 1 gallon to 30 of water. Lime-sulphur, summer strength, for apples and pears; dilute the commercial preparation, 1 gallon to 40 of water, and for plums, cherries, etc., dilute the commercial preparation, 1 gallon to 60 or 65 of water. As the use of lime-sulphur sprays on plums and cherries during the growing season is still in the experimental stage, a few trees should be tried first to see the effect.

In storing commercial lime-sulphur, it should be kept in a tight container, as it deteriorates when exposed to the air for some time.

Self-boiled Lime-sulphur.—For the summer spraying of peaches, apricots, and plums for peach-scab, peach-mildew, apricot-scab, and brown-rot of plums this mixture is to be recommended. It may be prepared as follows:—

Fresh stone-lime	8 lb.
Sulphur (flour, or flowers)	8 lb.
Water	40 gals.

This is best prepared in quantities of 24 or more pounds at a time. Place 24 lb. of lime in a barrel, add enough cold water to keep the lime slaking well, and dust 24 lb. of sulphur, which has been first worked through a screen to break the lumps, over the lime; then add enough water to complete the slaking. Stir well with a hoe to prevent the lime from caking on the bottom. As soon as the slaking is over, add enough cold water to cool the whole mass and prevent further combination of the lime and sulphur. Dilute with enough water to make up the strength of the above formulæ. Strain diluted mixture through sieve into spray-tank and agitate well when using.

Dry Sulphur is sometimes used as a fungicide to check the spread of mildews and brown-rot on plums, cherries, etc. For this purpose it is dusted on the tree, or vine, when the disease is first noticed. It is doubtful whether this is practicable on a large scale.

Potassium Sulphide (liver of sulphur) is sometimes recommended for the control of mildews. Use 3 to 5 oz. of the above to 10 gallons of water. It does not spot the foliage or fruit.

Ammoniacal Copper Carbonate.—Sometimes used where spraying is necessary when fruit is nearing maturity. Use 5 oz. of copper carbonate with just enough ammonia to dissolve it. Dilute with 40 gallons of water. If the ammonia is very strong it is advisable to dilute it with water before adding to the copper carbonate.

Bordeaux Mixture.—Where Bordeaux mixture is to be used in quantity it is advisable to make stock solutions. To make a stock solution of copper sulphate, put 20 gallons of water in a 40-gallon barrel; place in sack (preferably of a coarse nature, such as a light bran-sack) 80 lb. of copper sulphate (bluestone); suspend this in a barrel so that the bottom of the sack is 5 or 6 inches under water. In a few hours, or at least a few days, the copper sulphate will go into solution. Mark on the inside of the barrel the surface of the solution, so that if any evaporation takes place it can be replaced with water to make up the original quantity. After the copper sulphate is all dissolved each gallon of the solution will contain 4 lb. of copper sulphate. This proportion is given as an example, but any quantity can be used to suit the requirements of the maker. It is not desirable to dissolve more than is required for a month's use, as it will become weak through recrystallization at the bottom of the barrel and require dissolving again. Use only brass or wooden vessel as a container.

Lime.—Only good fresh stone-lime should be used. This can be made into a stock solution also. In slaking the lime, use just enough water to make it slake rapidly without being allowed to powder, which indicates burning through lack of water. Watch the lime carefully while slaking and keep it stirred. If the lime is not first quality, better results will be obtained through the use of hot water. If the above directions are carried out, the result should be a smooth white paste which, when water is added, will strain readily. Dilute the milk of lime with water, so it will be possible to know how many pounds of stone-lime is in each gallon of the lime-water. Mark barrel to allow for evaporation, as in the case of the copper-sulphate solution.

After the stock solutions have been prepared, to make the 4-4-40 Bordeaux mixture, proceed as follows: Use two barrels besides the spray-barrel. In one barrel put 1 gallon of the copper-sulphate solution, which, according to the strength of the solution as described above, will contain 4 lb. of bluestone. Dilute this to 20 gallons by adding 19 gallons of water. In the other barrel place stock solution of lime containing 4 lb. of lime, and dilute with water to make up 20 gallons. Stir both of these well and then pour them into the spray-barrel, so that the two liquids will unite as they enter. By following these directions carefully a Bordeaux mixture will be prepared which will stand in suspension well, stick well to the tree, and be effective. It is advisable to use this mixture within a few hours after making. It is advisable to strain the mixture as it goes into the spray-barrel. For this purpose a brass strainer fixed in a cone shape in the bottom of a pail with an outlet is

very satisfactory. By pouring the mixture on the top of the cone it will strain readily with little clogging, and is more satisfactory in this respect than a flat strainer.

The following tests are good ones to show whether the copper sulphate has all been neutralized by the lime:—

Potassium Ferrocyanide (in Solution).—No change on adding to mixture. If more lime is required, it turns a purple or reddish colour.

Blue Litmus-paper.—No change. If it turns red, more lime is required.

Knife-blade.—If metallic copper precipitates on the blade, the mixture requires more lime. The potassium ferrocyanide is the best and cheapest indicator.

Bordeaux mixture, double strength (8-8-40), is to be recommended for fall spraying for the black-spot canker. The ordinary mixture is a valuable spray for potato-blight and various other vegetable-diseases.

Sticker—

Resin	2 lb.
Sal soda	1 lb.
Water	1 gal.

Boil this mixture until it is of a clear brown colour, which takes from one to one and a half hours. Cook in an iron kettle in an open place. Add the above to 40 gallons of Bordeaux for use on smooth foliage, like onions, cabbage, or asparagus. If used with arsenate of lead or Paris green, add 1 to 2 lb. of fresh lime to every 40 gallons.

Soluble Sulphur.—This is a patented preparation containing 58 to 60 per cent. soluble sulphur and 40 to 42 per cent. inert matter. It is recommended by the manufacturers as a spray to take the place of lime and sulphur. The compound comes in dry form in various sized packages and is easily handled. For winter spraying the strength recommended is 1 lb. soluble sulphur to 4 gallons of water, and for summer spraying 1 lb. to 40 gallons of water. Some growers have reported good results with this spray, but, on the whole, the results of the experiments carried on for two years by the Department have been varied and conflicting.

Atomic Sulphur.—A spray manufactured by the General Chemical Company of California and recommended for the summer spraying of fruit-trees, especially those with tender foliage. It is recommended for practically everything that lime and sulphur is used for during the summer and is reported giving good results. It has not been used to any extent in this country, but is worthy of trial for the powdery mildews on apples and peaches.

Precipitated Sulphur.—After testing out all standard fungicides and many new preparations this spray gave the best results in California in the control of apple-mildew. In the tests made it was prepared as follows: 2 lb. iron sulphate dissolved in 10 gallons of water. To this add concentrated lime and sulphur slowly until no more black precipitate is formed; allow to settle and pour off clear liquid. Water is added again and the same operation is repeated two or three times. The black precipitate is then mixed with 100 gallons of water and used as a spray. Arsenate of lead and nicotine sulphate can be used with this mixture without impairing its fungicidal value. Some fruit-growers in Hood River report good results from adding the iron sulphate and arsenate of lead to the lime-sulphur after the latter is diluted in the spray-tank.

Combination Sprays.—It frequently happens that the time to spray for some biting or sucking insect coincides with that for a fungus-disease. It is therefore possible by combining various sprays to make one operation do the work of two or even three. The following has been successfully used against aphides, scab, and leaf-eating caterpillars: Lime-sulphur (concentrated), 3 gallons; 40-per-cent. nicotine sulphate, ¾ pint; lead arsenate (paste), 5 lb.; water, 100 gallons. The foregoing spray gives the best results in the Dry Belt when applied immediately before the blossoms open. If any of the ingredients are not necessary they may be omitted.

NOTE.—Never add soap to a spray containing lime-sulphur.

DISINFECTANTS.

(FOR WOUNDS ON TREES AND FOR PRUNING-TOOLS USED FOR BLIGHT.)

Corrosive Sublimate, 1 part to 1,000 parts water. Best to get tablets at the drug-store; use tablets as recommended by the druggist, as they vary in size, one tablet to a pint of water being sufficient in some cases. In others three or four are necessary.

Corrosive sublimate is highly poisonous when taken internally. It corrodes metals and must be used in wooden or glass vessels.

Formalin (Formaldehyde) is useful in the disinfection of seed; e.g., against grain-smuts. Formalin should not be used as a disinfectant in fire-blight work.

SPRAYING MACHINERY.

The value of a spray outfit does not depend so much on the work it is capable of doing as on the competency of the man using it. Just as good work has been accomplished and results obtained with a barrel hand-pump as with a power-sprayer. Both good and poor work is being accomplished every year with all types, depending largely on the efficiency of the man in charge. With this in view it would be useless to go fully into the question of spray outfit and make any recommendations, as it is difficult to know who the reader will be. However, there are a few general principles with regard to their purchase which are worthy of mention.

In selecting an outfit the fruit-grower should not select his type from the standpoint of his present necessities, but should consider his requirements for the near future, during at least part of the lifetime of the outfit. It should be simple in construction (so it will not require the services of an expert mechanic to adjust it), strong, easily worked, easily cleaned, and one in which high pressure can be maintained. This latter point, though possibly not of any great importance as far as the majority of our orchard pests are concerned, is important, as it influences greatly the labour cost of spraying. Double pressure decreases considerably the time required for spraying, and it will be noticed in the cost of spraying as given below that labour is an important item.

Always wash out thoroughly and drain the spray outfit after using. This will save a lot of trouble and time.

Some essentials in a good spray outfit are:—

(1.) The pump, etc., should be simple, strong, and easy to adjust.

(2.) The pump should be lined with brass, or some material which will not be corroded or rusted by the spray mixture.

(3.) The air-chamber should be of sufficient size to maintain a uniform pressure, and strong enough for high pressure.

(4.) A good agitator is required, as the fungicidal and insecticidal value of most of our sprays is contained in the fine particles held in suspension in the water.

(5.) A good strainer is necessary, especially where lime is used. The cone-shaped strainers have been found to be the most satisfactory.

(6.) Good strong hose only should be used. The best is none too good.

(7.) *Nozzles.*—Two types of nozzles are in common use and are giving good results—the Bordeaux type, which delivers a flat driving spray, and the Friend type, which delivers a circular spray. When spraying for codling-moth, or when winter spraying old trees with shaggy bark, bad crotches, etc., a high-pressure driving spray is best, and the Bordeaux nozzle is the one to use. For summer spraying when the chief object is to cover a large surface or on young trees with a smooth bark, the nozzles which deliver a circular spray, as the Friend, Bean Jumbo, etc., are the most economical ones to use.

It is well to have the nozzle on the rod at an angle of 45 degrees, as this greatly facilitates spraying.

COMPARATIVE VALUES OF SPRAY OUTFITS.

Tables showing comparative values of spray outfits are given below. These will vary greatly according to the machine used, grower using it, age of trees, facilities for mixing, topography of land, etc. They are given as a basis for figuring values, and to show that the labour cost is the main item in spraying. The value of the larger outfits, other than shown here, is that less time is taken in the application of the spray, which is an important consideration, especially when fighting some of the pests, less labour is required per acre sprayed, higher pressure is obtained, and, as a general rule, more thorough spraying is accomplished.

BASIS: 2,000 AND 10,000 GALLONS OF SPRAY.

Power Outfit—

Initial cost $450 00

Number of gallons per day, 1,200.

	2,000 Gals. Spray.	10,000 Gals. Spray.
Interest on investment at 8 per cent.	$ 36 00	$ 36 00
Depreciation in value at 10 per cent.	45 00	45 00
One and two-third days, three men at $2.50 ...	12 50	62 50
One and two-third days, team at $3.50	5 87	29 35
Three gallons gasolene at 30 cents	0 90	4 50
Total cost	$100 27	$177 35

Duplex Hand-pump—

Initial cost ..... $ 70 00

Number of gallons per day, 600.

	2,000 Gals. Spray.	10,000 Gals. Spray.
Interest on investment at 8 per cent.	$ 5 60	$ 5 60
Depreciation in value at 10 per cent.	7 00	7 00
Three and one-third days, three men at $2.50 ...	25 00	125 00
Three and one-third days, team at $3.50	11 75	58 75
Total cost	$49 35	$196 35

BASIS: 15,000 GALLONS SPRAY.

Power outfit	$225 00
Duplex hand-pump	288 00

COST OF LABOUR PER GALLON TO SPRAY IN LARGE OKANAGAN ORCHARD.

Two men and team with power outfit spray out 1,000 gallons per day.

Two men at $2	$4 00
Team at $2.50	2 50
	$6 50
Cents per gallon for labour	0.0065

In this case only two men are used to do all the work, and the teamster is done away with. Under a great many conditions the work can be done cheaper than this. In this instance water was not very handy to some parts of the orchard, and no supply-tank was used.

COST OF LABOUR AND MATERIAL FOR SPRAYING 300 PRUNE-TREES TEN YEARS OLD.

300 gallons lime-sulphur 1-30	$ 4 50
Three men, one day at $2	6 00
Team at $2.50	2 50
	$13 00
Cents per gallon for labour	0.944

COST OF SPRAYING 500 APPLE-TREES TWENTY YEARS OLD.

2,750 gallons of spray were used, lime-sulphur 1-30.

Material	$22 91
Three men, two and a quarter days at $2	13 50
Team, two and a quarter days at $2.50	5 63
	$42 04
Cents per tree	8.04
Cents per gallon for labour, about	0.7

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